FOOD AND NUTRITION

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FOOD AND NUTRITION

BY

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PREFACE TO SECOND EDITION

A SECOND EDITION has afforded me the opportunity to revise and make alterations in the text in accordance with more recent research, statistical investigations and statutory instruments. Research on foods and their nutritive values has gone on apace, the timely appearance of a *British Journal of Nutrition* has afforded a valuable means for its presentation. The difficulty, always present, of selecting from an ever-growing mass of experimental work the most essential and appropriate evidence has by no means diminished. It will be apparent that in many parts of this book brevity must of necessity leave gaps in both information and experimental evidence; to fill these gaps references have been given to scientific papers and books.

As on a previous occasion, I am indebted to many who, by reprints, personal communications and suggestions, have kept me abreast of recent work in their respective fields. I should like to express my indebtedness to Dr. H. E. Magee of the Ministry of Health for his continued interest and help, as also to Dr. E. R. Bransby and Dr P. J Cowin, both of the Ministry of Health. To Professor G. S. Wilson I am indebted for papers and recent statistics on tuberculosis; to Dr. F. Kidd, F.R S., and Dr. T. N. Morris of the Low Temperature Research Station, Cambridge, Dr. G. A. Reay, O B E, of the Torry Research Station, Aberdeen, Dr. J. A. B. Smith of the Hannah Research Institute, Ayr, Professor H. D. Kay, F R.S., of the National Institute for Research in Dairying, Shinfield, Dr. R. G. Tomkins of the Ditton Laboratory, D.S.I.R. Food Investigation, East Malling, Dr. C. H Chalmers of St. Andrew's House, Edinburgh and Dr. T. Schulz of the Institute of Statistics, Oxford I am indebted for memoranda and papers on past and present work in which they have been directly or indirectly engaged. I should also like to thank Dr. T. Moran, C B.E., of the Cereals Research Station, St. Albans, Dr. J. R. Nicholls, Deputy Government Chemist and Dr. J. R. Fraser of the Government Laboratory for information concerning national flour, and Dr. J. J. C. Hinton of the Cereals Research Station, St. Albans, for the results of his most recent work on wheat and rice grains and for Figure 21.

It is a pleasure to acknowledge several official publications on nutrition in India sent to me through the kindness of Dr. Amrit Kaour, Minister of Health, New Delhi, to thank Dr. W. R. Aykroyd, Director of the Nutrition Division of the Food and Agriculture Organization, Washington, for permission to make use of illustrations —Figures 1–4—indicating changes in world consumption of nutrients, the Ministry of Food, who through their various Offices have been most helpful and the British Baking Industries Research Association for the most recent analyses of National flour, the National loaf and wholemeal bread.

I wish also to thank authors and publishers for permission to use Figures, a detailed acknowledgment of which is given in the text, and Mr Macmillan and Mr. Parker of Messrs. E. & S. Livingstone Limited for their unfailing courtesy and helpfulness.

E. W. H. CRUICKSHANK.

MARISCHAL COLLEGE,
ABERDEEN, *May*, 1951.

PREFACE TO FIRST EDITION

In presenting a brief survey of our present knowledge of the physiology of Food and Nutrition and of the means whereby this country met the problems of feeding the nation during six years of war, I have had in mind medical practitioners, medical students and those of the general public who are particularly interested in the part food plays in promoting and maintaining the welfare of the individual as well as that of the nation. The recent ideas of the General Medical Council concerning the training of candidates for the Diploma in Public Health have also been borne in mind. The suggestion that they should be given courses in the Physiology and Biochemistry of Food and Nutrition means that they must have a knowledge of the physiological bases of nutrition, dietary planning and the social and economic aspects of food.

A strong belief in the value of historical knowledge in understanding the development and significance of modern scientific investigation has led me to introductions of certain parts of the subject which may be considered all too brief. For those who feel disposed to criticize such brevity references are given. An equally strong belief in experimental evidence may, in the eyes of the general reader, appear to have led me into unnecessary by-paths, but the evidence of experiment is all important and so great is the bulk of it in nutrition to-day, that selection presents an ever growing difficulty. During six years of war the experimental field of nutrition has been extended in many interesting directions To some of the work reference has been made, but much still remains to be published. The body of evidence concerning nutrients, food processing and nutrition in relation to human well-being continues to grow so rapidly that the time is ripe for a British Journal of Nutrition.

War has emphasized with harshness and urgency what political reform has envisaged for many years, namely, the need of a greater production and better distribution of food in the interests of the nutritional status of our people. The hope of peace demands that, in the international sphere, this principle be not lost sight of. To this end, and with commendable vision, the United Nations Conference on Food and Agriculture convened at Hot Springs, U.S.A., in

May, 1943, resolved upon the formation of a World Food and Agriculture Organization This Organization was established on October 16, 1945, with Sir John B. Orr, F.R.S., as its Director-General, and with its creation the first plank to bridge the gulf between War and Peace had been fashioned. Naturally it is not the only plank required to bridge this great gulf, but it is, at present, the only one apparently sufficiently well prepared to bear the weight of responsibility it is destined to carry. It may not be too much to say that the hope of World Peace depends upon it.

In gathering together scientific and medical data one soon becomes aware of one's indebtedness to others. I should like to express my thanks to those who by reprints or personal letters have kept me informed as to the latest developments in their respective spheres of research and to those who, in this country and abroad, have so willingly granted me permission to use their illustrations.

I am indebted to Sir Joseph Barcroft, F.R.S., Chairman of the Food Investigation Board, Dr. Franklin Kidd and Dr. T. N. Morris of the Low Temperature Research Station, Cambridge, Dr. George A. Reay of the Torry Research Station, Aberdeen, Dr. B. S. Platt of the Division of Human Nutrition of the Medical Research Council, and Professor H. D. Kay, F.R.S., of the National Institute for Research in Dairying, for much interesting and very recent information on the dehydration and preservation of foods.

My thanks are due to the following authors and publishers for permission to reproduce various figures and illustrations: Dr. Bernard Read of the Lester Institute, Shanghai, for Figs. 18 and 19, Dr. Harriete Chick for Figs. 22, 25, 26, 27, 28, 29, Dr. S. L. Simpson for Figs 20 and 21, Dr. Donald Hunter for Figs. 23 and 24, Lady and Sir Edward Mellanby, F.R.S., for Figs. 37, 38 and 39, Professor R. A. McCance for information concerning, at the time unpublished, work on the analyses of Manitoba and English wheat. Sir Jack Drummond, F.R.S., and Dr. T. Moran for personal communications and Figs. 8 and 31. Dr. W. R. Morse (New York) for Figs. 15 and 16, Drs. Harris and Birch for Fig. 17, Drs. Bate-Smith, Sharp and Cruickshank for Fig. 35, Dr. Davidson, Chief Medical Officer of the Department of Health for Scotland, and Mr. Donaldson of the Ministry of Food, for permission to publish the data in Tables 50 and 51 respectively, and Professor Dugald Baird for Figs. 40 and 41.

I am also indebted to the Director of Publications of H.M. Stationery Office and the Publications Officer of the Medical Research Council for permission to use illustra [illegible]

of Physiology for Fig. 12, the Editor of the *British Medical Journal* for Figs. 10 and 29, Messrs. J. and A. Churchill for Fig. 11, Messrs. Wm. Heinemann for Figs. 23 and 24, Mr. MacLennan of British Cod Liver Oil Productions (Hull) Ltd., for Fig. 30, and the Aluminium Plant and Vessel Co., Ltd , for Figs 33 and 34.

I should also like to express my thanks to Sir John Orr, and Dr. Leitch, of the Imperial Bureau, for information concerning the future plans of the Food and Agriculture Organization and to Mr. L. Simpson of the Reid Library (Rowett Institute) for valued help on many occasions.

E W. H. CRUICKSHANK.

Marischal College,
Aberdeen, April, 1946.

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CHAPTER I

INTRODUCTORY

THE EVOLUTION OF HUMAN DIETARIES

THE evolution of the dietaries of man has had a distinct and characteristic influence upon the development of man himself. In the Simian Period, the Primates, because of their prehensile powers, fed chiefly on fruit, beans, roots and to some extent on birds and small mammals. When, in the course of time, man began to employ special devices in hunting and fishing, he became less dependent upon vegetable food and more and more dependent upon animal food. In doing so, he lost, to a great extent, his power of digesting what would now be regarded as most indigestible and unpalatable forms of vegetable food. In those early prehistoric days, a good nutrition must have waited upon good mastication, for in prehistoric man an excellent masseteric musculature and salivary mechanism were associated with a dental array which may have been as alarming as it undoubtedly was efficient. Certainly in those days much of the salivary digestion was carried on in the mouth and not, as to-day, relegated almost entirely to the small intestine. A marked step forward in the evolution of dietary habits was taken when man learned to cook. In so doing he increased his food supply, lessened the time required for mastication, increased the amount of vegetable food taken, but lost to a large extent his power of digesting raw foods. There still exist in the world to-day peoples who are representative of this period in the evolutionary history of man They are the Bushmen of South Africa, the Veddahs of Ceylon, certain American Indians and the Esquimaux. While geographically and ethnologically separated, their mode of eating is proof of their common origin. Before the advent of the use of boiling water in cooking, man used surface fires and underground ovens. In certain parts of the world, for example, in New Zealand, boiling pools afford an excellent means of cooking, but it was not until man created for himself receptacles which would both hold water and resist heat, that he was able to boil water in

order to cook his food. Not only by a remarkable resourcefulness and ingenuity did man select the food which he desired to cook, but he soon learned how to extract starch or sugar from foods rich in these substances. In the pre-agricultural period of man's existence, there appears to have been no knowledge of the art of making beverages, at least not of the art of making alcohol.

In the course of his long prehistoric existence, man had noted the quick passage of the sun, the slower motion of the moon and the long cycle of the great stars. The impression which these heavenly bodies must have made upon his mind, clouded and dominated by superstition and fear, must have been tremendous. In noting the equinoctial position of the sun, sensing the meaning of springtime in the regularly recurring outbursts of new life around him and ultimately realizing the significance of the cycle of the seasons, primitive man awoke to the meaning of springtime and harvest. The first experiments in agriculture had begun. No longer did he rely entirely upon the forests, the lakes, the rivers and the sea for his food, but he began now to assure himself of a regular and known supply of his material needs. Naturally at first, being still a migratory animal, his efforts in agriculture were doubtless spasmodic and limited, but as primitive digging implements of wood and bone gave way to the neolithic tools, the pick, the adze and the axe, a period of more stationary agriculture was introduced. In the migratory period, man had learned how to rear animals, to tend herds and to secure for himself a very valuable mammalian source of food supply. He had throughout the long process of the conquest of the seasons succeeded in securing for himself a mixed animal and vegetable dietary. His fortuitous existence as a primitive Primate had ended and he had entered upon that period of neolithic development which was to be the forerunner of the ancient civilizations of China and Egypt (*ca.* 4000 B.C.).

The Effect of Climate, Racial and Religious Differences upon Dietary Habits.—Throughout the agricultural period, as he continued to develop the cultivation of cereals, cane sugar and fruit, man came to rely less and less upon raw vegetables. As populations increased and tribes wandered farther and farther into the unknown seeking new areas for cultivation and developing new crafts, greater variations in dietary customs

became manifest. In the tropics a purely vegetarian mode of existence contrasted strongly with the carnivorous instincts of those who had elected to live their lives in the cold and less sunny regions of the arctic and sub-arctic climates. There were, of course, intermediary groups who did not rely entirely upon either fruits and vegetables or on cooked seal, walrus and whale. To climatic variations were added those of race and religion. The racial differences are more difficult to explain. Not only do we find primitive peoples who, like the aborigines of Australia, are very fond of putrid, fatty flesh, be it fish or fowl, or like the natives of Tierra del Fuego who, according to Darwin in his *Voyage of the Beagle*, regard the floating carcase of a putrid whale as a rich feast in store, but, on the other hand, we find less primitive peoples, such as the Veddahs of Ceylon, [illegible]

are the Chinese, a people of ancient culture for whom milk and butter appear to have but little attraction.

In the religious sphere we find the Buddhist, to whom the taking of life is strictly forbidden, and for whom, in China and Japan, and in India, the home of Buddhism, the eating of certain fish has become a quite orthodox custom. To-day the traditional attitude of avoidance of pork and alcohol by orthodox Mohammedans is well known The Levitic Law stands pre-eminent as an example of priestly dictation in the interests of public or tribal health. What was once declared "unclean, an abomination", was strictly avoided, ultimately to become abhorred. Several animals, including the camel, the coney, the hare and the pig, many birds, fish without scales or fins, are to be found in this priestly category of things forbidden (*Leviticus*, Chap. II). It would appear that in the long history of the development of dietary habits, there has been a steady tendency in temperate climates to replace vegetable food by a greater dependence upon animal food. It has often been stated, with what truth we are free to surmize, that animal food has played a decisive part in human evolution. Perhaps too much stress has been laid upon this aspect of evolution, but nevertheless it is true that animal protein foods do exert a stimulating effect upon the complex of chemical processes within the body. To secure all the elements of the proteins

necessary for body-building, much more of vegetable than animal protein must be eaten. These animal foods, in conjunction with geographic position and climatic conditions, have a very important ethnological significance. That this is true of man is borne out by the appearance and disappearance of certain races, tribes and communities. Some races are tall, healthy and long-lived; others are puny, disease-ridden and prematurely senile. Heredity does, and always will, play an important part in determining human stature and health; but climate also plays a part, even if a small part, in determining physical and mental characteristics, and it must now be accepted that diet also plays its part, a fact which in the opinion of some outweighs both heredity and climate combined. One of the most interesting reports on the part played by diet in the development of races has been published by the Medical Research Council of Great Britain. It is a study of the physique and health of two African hill tribes in Kenya, by Lord Boyd-Orr, then Sir John Orr and Dr. Gilks. One tribe, the Kikuyu, is vegetarian; the other, the Masai, is carnivorous. The Kikuyu tribe is agricultural, and, although the natives possess large herds of goats, they practically never eat meat. Meat is the diet of the old men of the tribe, the others live on cereals, tubers, plantains, legumes and green leaves. Sixty per cent of the diet of the males consists of maize and millet. The Masai, on the other hand, are a pastoral tribe; the staple diet of the young men consists of meat, milk and blood; the older people eat bananas, beans, maize and millet. It is interesting to note the physical characteristics of these two tribes, the one vegetarian, the other meat-eating. At every age the Masai tribes are taller and heavier than the Kikuyu; at the age of twenty-three years there is an average difference of five inches in height. At the same age the Masai women are three inches taller than their vegetarian neighbours. Measurements of physical strength show that the Masai present a marked superiority, the Masai women even being as strong as the Kikuyu men. Interesting are the diseases to which these tribes are prone. Dental caries is not common in either, but it is more prevalent in the Kikuyu children. Anæmia, unknown amongst the Masai children, is prevalent among the Kikuyu children. Bone deformities, as one would expect, are absent from the Masai, but definitely present in the Kikuyu. The resistance to

tropical diseases, tuberculosis and pneumonia is greater in the meat-eaters, but the prevalence of rheumatic troubles, arthritis and constipation is very marked in the Masai, troubles which are not to be found amongst the vegetarian Kikuyu. Before the white man came, the Masai lorded it over their puny neighbours; they were a fearless tribe; to hunt lion with only a spear was a common task of this virile tribe. The moral to be drawn from this comparison is that meat in moderation is an excellent adjunct to milk, green vegetables and cereals.

Such results are not confined to Kenya, but can be obtained throughout India, where various races subsisting on different diets afford great opportunity for investigating the numerous problems associated with nutrition and national health. The diets of Bengalis, Sikhs and Pathans vary in certain respects and comparing their dietaries, relative to their build and mode of life, one can see how diet does play a part in the development of the physical and mental characteristics of people

The Impact of Social Conditions in Britain on Food and Feeding.—Having looked at the broad lines of development which have led up to distinct racial and tribal differences, we may now consider the progress in dietary advance in this country in its relation to social conditions In mediæval times a clean-cut distinction existed in almost all respects between the Lord of the Manor and the common people. The crops grown on the manor lands by the common people were wheat, barley, oats, rye and beans. In the south, wheat and rye were the principal crops and these were often from mixed sowing, and from this fact arose the word "maslin" (Latin, *miscere* = to mix) which denoted the finely ground and sieved flour obtained from these crops In the fourteenth century there is evidence of the cultivation of vegetables and fruits in England. This was a late development compared with what obtained in France and Italy, where by that time gardens were plentiful. In all circumstances, livestock, supporting the animal protein requirements of the people, were kept by landowners.

In the fourteenth and fifteenth centuries the bondage of serfdom slowly disappeared and we find a steady increase in tenant farmers and yeomen. By the system of Tudor enclosures, resulting from the growth of the wool trade, arable land was sacrificed to an astonishing degree to increase grazing, and much economic distress was caused thereby. This was accompanied

by a deterioration in the diet of the common people. The lack of grazing lands led to a decrease in dairy cows, which were the source of the "white meats" as dairy produce was called. This period of depression was probably responsible for a remarkable increase in gardening in which the Dutch were particularly skilful. With the growing of fruits, vegetables and potatoes and the improvement in agriculture which accompanied the increasing stability of the realm under Elizabeth, the diet of the common people living on the land and in the small towns again improved. In the larger towns, however, and particularly amongst the urban populations of large cities like London and York, the quality of the food was very bad and the practice of food adulteration grew to a scandalous extent.

Tudor days saw the first attempt to bring fish from the coastal towns to the large cities. The results were, to say the least, unsavoury. Putrefaction, with its attendant odours, or the odour itself, was regarded as the cause of the frequent outbreaks of plague so notable a feature of the fifteenth and sixteenth centuries. The trade in herrings was considerable —they were cheap, 40 a penny—and herrings with, occasionally, salmon, formed a valuable addition to a diet, not good in the large cities but on the whole very good in coastal and rural areas.

Before the nineteenth century, bread was made from wholemeal flour prepared by stone grinding, the coarse particles of the bran being removed by "bolting" through linen or woollen cloth of various degrees of coarseness. The more finely this flour was sieved the lighter in colour it became until the finest quality was of a pale cream colour. In the Tudor period this flour was called "manchet" and it became the sign of a type of living associated with the Court and later with the families of the rich.

Reference is made not infrequently to the peasant's diet of the fifteenth and sixteenth centuries, emphasis being laid upon its wholesomeness. Wholemeal bread and fruits in season were eaten freely. Vegetables and potatoes did not then bulk largely in his diet and it is for this reason that scurvy was a prevalent disease. If the peasant could secure a goodly supply of "the white meats", milk, whey, cheese and eggs, then regarded as a low class diet, he had a diet which was far superior to that eaten by many of our working classes to-dav.

The formation of the East India Company in 1600 may be regarded as the first official pronouncement that England was to prosecute oversea trade far beyond the limits hitherto covered by such chartered companies as the Turkey Company (1581) and the Russian Company (1566). Throughout the seventeenth century this trade grew apace and in the eighteenth century became the open sesame to the great developments of our commercial and colonial empire. Our navy virtually commanded the seven seas and our merchant ships traded to the four corners of the earth, opening up tremendous possibilities for wealth, and bringing ever new ideas which had their effect on the diet and social customs of the peoples of these islands.

In the realm of our national dietary two changes amongst many were noteworthy—the importation of tea and sugar. Three hundred years ago sugar was unknown as an article of diet. In the days of Marie Antoinette it was an expensive luxury sold at about 4s. or 5s. per lb. At the end of the Napoleonic wars, which had cut Europe off from her source of sugar supplies, France and Germany had established the manufacture of sugar from beet, but English people had insular prejudices concerning beet sugar and were apparently content to pay dearly for cane sugar which for them was rapidly becoming a necessity. The history of sugar is the history of a habit-forming foodstuff. As sugar consumers we run a very close second to the people of the North American Continent. From 1836 to 1936 the consumption of sugar rose in this country from approximately 10 to 100 lb. per head per annum. The great increase in the use of sugar has not been without its effect upon our taste for other and better foods. The craving for sugar has led to the use of unbalanced diets, for sugar eaten in excess destroys the appetite for those foods which supply the all-essential proteins, vitamins and mineral salts. From being a rarity sold by the Pepperers, the predecessors of our grocers, sugar has become the cheapest available source of energy.

Another of the striking changes in English dietary habits was the adoption of tea-drinking. Coffee introduced from Turkey and chocolate from the West Indies had become established as beverages in the seventeenth century. Tea from China and the Dutch East Indies was first sold in England at £3 10s. per lb. So quickly did it gain in popularity that it soon became coupled with coffee and chocolate in the numerous

London coffee houses where men from every walk of life congregated. When the East India Company began to bring large consignments of tea from India and China, the price fell until at the end of the seventeenth century it cost approximately 2s. per lb. It was then drunk as in China to-day, that is, as a weak infusion without milk or sugar, and the habit grew to such amazing proportions that by the end of the eighteenth century it was an established drink among all classes. It has been said that the enormous consumption of tea was a source of anxiety to the brewers. Well it may have been, but, if it caused a certain diminution in the abominable addiction to spirits, gin mixtures and beer, it did well, for the drinking habits of the people of England during the eighteenth century were causing untold misery, illness and such general squalor that the terrible picture of Hogarth's "Gin Lane" is a revelation as true as it is appalling. While some regarded the excessive drinking of tea as harmful, almost as iniquitous as gin drinking, others were of the opinion that by "tea drinking and regular living, the Distemper of England (i.e. scurvy) may be cured". With these two develoments in dietary habits both tea and sugar rapidly became the cheapest of foods, and the consumption of coffee, cocoa and chocolate was markedly reduced, with the result that the famous coffee houses slowly disappeared.

Had it not been for war and political strife, the seventeenth century would have seen great strides in the betterment of the lives of the poorer people of England. Agriculture continued to develop, trade and commerce brought wealth to not a few, landed gentry appeared, and the middle and upper classes fed well and continued to feed well, in marked contrast to the steady decline in the standard of living among the "lower classes". It was a curious anomaly of the seventeenth century that the type of food considered as proper for working men, butter, cheese, oatmeal and beer, was generally never seen by them and was not regarded with favour by the upper classes. These foods would make an excellent diet, but were unknown to the mass of dwellers in the cities and towns, who were rapidly being introduced to the evils of food adulteration, spirit drinking, and bread made from sifted wholemeal flour. The diet of the people who could afford to spend money on food consisted chiefly of meat, bread, cheese, butter and beer. Except for cooking, butter was not used by the wealthy classes. Old English ale,

still much in popular use, was rapidly passing from the tables of the rich. Home-brewed beer was a good source of calories but not of vitamins. At Christ's Hospital boys received about three pints of beer daily, which supplied some 500 of the approximate 2500 Calories required. Christ's Hospital had thus early begun to show a progressive interest in matters relating to nutrition, an interest which has continued to this day and has been the source of much valuable nutritional data.

In the eighteenth century the swift application of mechanical inventions in industry, the increase in population, the continued drift of the agrarian population to greater employment in the towns and cities, called for a larger food supply, and thus agriculture was forced to develop. National wealth increased as a result of the agricultural and industrial revolutions, but prosperity was shared only by the landowners and manufacturers. As a result of intense competition the working classes in the new centres of population were crowded together in [illegible]

latter half of the eighteenth century the village labourers of the South, who subsisted mainly on bread, cheese and peas, were much worse off than those in the North, where potatoes and oatmeal were eaten with butter, milk or treacle. The diet, because of poverty and widespread adulteration of food, lacked vitamins, mineral salts and good protein, and was most unsuitable and insufficient for working men and women. While scurvy was being treated in the naval and merchant services by means of oranges, lemons and fresh vegetables, no one seemed to realize that a great part of the working population of the nation was living on the verge of starvation, many of them with manifest signs of scurvy and rickets—a poor preparation, indeed, for the long trial of the Napoleonic wars ! It was a situation in national nutrition which war and the continued industrial activity of the country were to aggravate almost to national disaster.

Notable as were the military achievements of the years which led up to the defeat of Napoleon, years in which, despite the loss of our continental trade, all the maritime traffic of Asia and America passed into our hands, none the less notable were the profound changes which took place in the social life of the people. The vigour with which wars were conducted on sea and land overshadowed the rapidity with which the social

changes were convulsing the nation. Had we not secured the whole of the maritime trade with Asia and America, our recovery would have been impossible: our post-war state would have been described in terms of bankruptcy and death. Naval and commercial supremacy gave us a monopoly of foreign trade, but the industrial revolution, fanned into renewed activity by new methods of transit, increasing use of machinery, and unwise legislation, made the opening years of the nineteenth century ominous indeed. Unrest was everywhere apparent, and anxiety for the future was not lacking amongst leaders of industry and members of Parliament. At the moment when the artisan was breaking th[illegible]
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ricks. The [illegible]
facing starvation, and only landowners, big farmers and industrialists and their children escaped the sordid misery of poverty and malnutrition which characterized one of the darkest periods *of English history. It was a time of mob violence, fanatical* hatreds, and dangerous class distinctions.

What of the diet of those men, women and children who had been driven by economic circumstances from the country into the towns, where houses were mere hovels, sanitation non-existent, food adulteration rife, and at a time when the importation of cheap cereal food was encouraged by those to whom low wages were a basis of profit? It consisted chiefly of bread, potatoes, and strong tea or "gin", with occasionally cheese and porridge or rotting vegetables and tainted meat. Milk they scarcely ever saw, which perhaps was to their advantage, for it was as highly infected as it was well watered, and was probably as dangerous as their drinking water—a constant source of epidemic disease. With the outbreak of potato disease in Ireland in 1846, there were sporadic outbreaks of scurvy in England, and thousands were living at starvation level. In Ireland, at least one-tenth of the population disappeared.

When, *for some, conditions began to improve in the latter* part of the nineteenth century, due to the continued expansion of trade and the slow but definite rise in wages, we find a change apparent in the food habits in certain quarters of the working classes. That "envy worketh subtle change" is no new discovery; here it was working to the detriment of the poor. The rich man of those days, often as grossly overfed as his

humbler fellow-creature was pitiably underfed, had introduced the typically English breakfast of porridge, fish, bacon and eggs, had delayed the hour of dinner from 2 p.m. to 8 p.m., and had instituted the *aperitif* of rum, brandy or bitters. Dire necessity doubtless being the mother of invention, the prescription for the morning after the night before was soon written: it consisted of Rochelle salts, infusion of senna and, if obtainable, a little Eau de Cologne. The rich man lacked nothing; in luxury he called the tune and in pain he paid the piper; this heaven-born individual ate white bread. It was made from stone-ground flour so thoroughly sifted that it had a pale cream colour. This was the flour known to England for centuries as the finest wheaten flour, from which was made the Manchet, i.e. the pale yellowish or cream-coloured bread of Tudor times This was the bread the artisans in the cities longed for; it was the emblem of superiority, the line of demarcation between the classes. This highly sifted flour was comparable to our modern roller-milled flour: it had lost all its vitamins and fat, half its mineral salts—calcium, phosphorous and iron—and some of its protein. To pass from the use of the coarsely sifted wholemeal flour to this highly refined substance brought disaster to

non-vegetable diet were appalling, and nowhere are they better described than in the words of Dickens: "pale and haggard faces, lank and bony figures, children with countenances of old men, deformities with irons upon their limbs, boys of stunted growth, and others whose long meagre legs would hardly bear their stooping bodies".

Throughout the Victorian era the nutritive value of British diets was good for those who could afford an adequate diet, bad for those who could not. It has been authoritatively stated that, at the end of the nineteenth century, the dietary "and the material state of our working people was probably worse than it had been since the great famines of Tudor times". Had the poorest classes in the second half of the century not

meat and potatoes or a greasy vegetable stew for dinner, with

changes were convulsing the nation. Had we not secured the whole of the maritime trade with Asia and America, our recovery would have been impossible: our post-war state would have been described in terms of bankruptcy and death. Naval and commercial supremacy gave us a monopoly of foreign trade, but the industrial revolution, fanned into renewed activity by new methods of transit, increasing use of machinery, and unwise legislation, made the opening years of the nineteenth century ominous indeed. Unrest was everywhere apparent, and anxiety for the future was not lacking amongst leaders of industry and members of Parliament. At the moment when the artisan was breaking the machinery which he regarded as the evil genius in his midst, the agricultural labourer was burning his employer's ricks. The great mass of a rapidly increasing population was facing starvation, and only landowners, big farmers and industrialists and their children escaped the sordid misery of poverty and malnutrition which characterized one of the darkest periods of English history. It was a time of mob violence, fanatical hatreds, and dangerous class distinctions.

What of the diet of those men, women and children who had been driven by economic circumstances from the country into the towns, where houses were mere hovels, sanitation non-existent, food adulteration rife, and at a time when the importation of cheap cereal food was encouraged by those to whom low wages were a basis of profit? It consisted chiefly of bread, potatoes, and strong tea or "gin", with occasionally cheese and porridge or rotting vegetables and tainted meat. Milk they scarcely ever saw, which perhaps was to their advantage, for it was as highly infected as it was well watered, and was probably as dangerous as their drinking water—a constant source of epidemic disease. With the outbreak of potato disease in Ireland in 1846, there were sporadic outbreaks of scurvy in England, and thousands were living at starvation level. In Ireland, at least one-tenth of the population disappeared.

When, for some, conditions began to improve in the latter part of the nineteenth century, due to the continued expansion of trade and the slow but definite rise in wages, we find a change apparent in the food habits in certain quarters of the working classes. That "envy worketh subtle change" is no new discovery; here it was working to the detriment of the poor. The rich man of those days, often as grossly overfed as his

humbler fellow-creature was pitiably underfed, had introduced the typically English breakfast of porridge, fish, bacon and eggs, had delayed the hour of dinner from 2 p m. to 8 p.m., and had instituted the *aperitif* of rum, brandy or bitters. Dire necessity doubtless being the mother of invention, the prescription for the morning after the night before was soon written: it consisted of Rochelle salts, infusion of senna and, if obtainable, a little Eau de Cologne. The rich man lacked nothing; in luxury he called the tune and in pain he paid the piper; this heaven-born individual ate white bread. It was made from stone-ground flour so thoroughly sifted that it had a pale cream colour. This was the flour known to England for centuries as the finest wheaten flour, from which was made the Manchet, i.e. the pale yellowish or cream-coloured bread of Tudor times. This was the bread the artisans in the cities longed for; it was the emblem of superiority, the line of demarcation between the classes. This highly sifted flour was comparable to our modern roller-milled flour: it had lost all its vitamins and fat, half its mineral salts—calcium, phosphorous and iron—and some of its protein. To pass from the use of the coarsely sifted wholemeal flour to this highly refined substance brought disaster to [illegible]

non-vegetable diet were appalling, and nowhere are they better described than in the words of Dickens: "pale and haggard faces, lank and bony figures, children with countenances of old men, deformities with irons upon their limbs, boys of stunted growth, and others whose long meagre legs would hardly bear their stooping bodies".

Throughout the Victorian era the nutritive value of British diets was good for those who could afford an adequate diet, bad for those who could not. It has been authoritatively stated that, at the end of the nineteenth century, the dietary "and the material state of our working people was probably worse than it had been since the great famines of Tudor times". Had the poorest classes in the second half of the century not been eating bread made from stone-ground flour, one can hardly imagine what their fate would have been. Amongst the middle classes the diet of porridge, bread, butter and tea for breakfast, meat and potatoes or a greasy vegetable stew for dinner, with

a supper of cheese and beer, may appear, at a superficial glance to be sufficient, but when the calorific value, the mineral and vitamin contents of these diets are calculated, there is no doubt as to their insufficiency. They lacked, sometimes in terrible measure, those factors which go to the building up of strong, healthy bodies in children and adolescents.

In any discussion of the dietaries at this dark time in English industrial history, we must clearly differentiate between farm labourers in the south of England and those in the north of England, Scotland and Ireland, as also between the artisan classes and the poor labourers who dwelt in the slums of great cities and small towns. The farm labourers of the north of England, Scotland and Ireland stood literally head and shoulders above all other classes, for the simple reason that they lived principally on wholemeal, milk and vegetables.

That these facts are true and that food in relation to physical fitness is not only an individual matter but one affecting the *state of health and efficiency of the nation, is revealed in the* available statistics concerning the height and weight of men, women and children. Medical examinations of recruits in war-time indicate fairly accurately the state of physique of the nation. In 1870 the minimal height for infantry recruits was 5 ft. 6 in. In 1883 it was reduced to 5 ft. 3 in.; in 1900, at the time of the Boer war, it was 5 ft. 0 in.! A Government Board of Inquiry instituted at this time by the Army Medical Authorities, on which the Royal College of Physicians and others were represented, came to the conclusion that since army rations contained a sufficiency of protein—125 grams per day —and of carbohydrates, and gave 3500 Calories per day, the fault could not be attributed to diet. A comparison of the nutritive values of a diet of white bread, butter, sugar, meat and tea or beer and that of a diet of bread and butter with milk and oatmeal in abundance will give the answer to the problem which went unsolved in 1904. It will show why London Military Authorities in 1900 favoured recruiting campaigns in the north of England, Scotland and Ireland. In the North, men of the countryside were bigger and stronger in those days because they had in their diets not only calories but an adequate supply of foods rich in vitamins and mineral salts. In this connection it may be observed that, according to Sir Thomas Middleton, "the peasantry of the Scottish Highlands, physically perhaps

the finest of the British races, until recent years consumed very little meat; their staple foods were oatmeal, milk and potatoes with herring and other fish in coastal parishes ". Unfortunately for us as a nation the dietaries of the great mass of the people have become more refined and lack, to a considerable extent, the essential nutrients in which the coarser diets are so rich.

In 1900 Seebohm Rowntree published a book called *Poverty: A Study of Town Life*. The town was York. The book is a classic in the literature of social economy. Its birth was naturally heralded at the time: it required a decade for the facts in it to arouse attention to the conditions in the slums of our large cities, where infantile mortality approached the appalling figure of 250 per 1000.

From such publications it was slowly forced upon us that the evolution of dietary habits was progressing along two clearly demarcated lines, one good, the other bad. Repeated examination of the latter showed that a too large section of the people of this country were undoubtedly suffering from malnutrition.

The food habits of the people of the United Kingdom have changed to the benefit of many; they had, until the second world war, remained unchanged to the detriment of not a few. During the past ten years we have learned how the benefits of wholesome food can be made available to all. If the most vicious expression of war's aftermath—hatred, prejudice and unrest—is to be avoided, the people must be adequately fed, housed and clothed All bodies responsible for Food, Agriculture and Education must continue to inform parents and others of the value of food and, above all, our schools must not fail in their duty to train children in the elements of nutrition.

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be claimed that good food or better feeding was the major factor in their passing. Good food demands the means to buy good food, and this monetary basis is not one of high salaries but of salaries proportionate to the cost of living or the achievement of an adequate standard of life, and this in turn depends upon a stable economic system.

In the midst of the increasing interrelationship of all things in a rapidly constricting world it is difficult to see how any economic system can secure for all mankind a decent standard of life unless it be created on an international as opposed to a national basis. The problem of the nutritional needs of the world as a whole can only be solved by international action. Let us look generally at the nutritional state of the world and then follow our statement by a brief summary of the plans envisaged for the relief of the millions of underfed people in Europe, Asia, Africa and America.

THE EVIDENCE OF MALNUTRITION

There are few countries in the world where social and public health services are so well developed or where there has been a more marked improvement in health and physique as in the United Kingdom. There was, however, in 1938, still evidence in this country of malnutrition in 25 to 30 per cent of the population. Nevertheless, that after five years of global warfare the nation was in remarkably good health simply showed that scientific advice freely taken will ultimately solve the problem of malnutrition in so far as food is concerned. That the health of the nation was so satisfactory at the end of the war was due to the fact that in 1940 the first large-scale application of the principles of the science of nutrition to the population of the United Kingdom was introduced as the war-time food policy of H.M. Government. To make this effective it was necessary to increase the home production of food, to import essential foods in suitable amounts, to ration the population according to its needs and industrial categories, to subsidize essential foodstuffs and to maintain adequate wages. Never before had foodstuffs supplying the physiological needs of the people been so uniformly distributed so that all classes, irrespective of income, had the opportunity to secure an approximately adequate diet.

CHAPTER II

THE PROBLEM OF WORLD MALNUTRITION

THE problem of world malnutrition is one of the most crucial tasks facing mankind to-day. It may not be too much to say that upon its satisfactory solution will depend the future peace of the world. At the Hot Springs Conference in U.S.A. (May-June), 1943, statesmen, scientists, economists and others discussed the various needs of world populations and set forth fundamental principles and general plans necessary to bring the world's food supply up to the level demanded by the generally accepted standards of nutrition. The problem is far greater than a mere increased production and a better distribution of food. Its ultimate implications are political, its present basis is the science of nutrition.

" Scientific discoveries in nutrition have shown how we can build a race of sturdy children, how we can see to it that the next generation will be as ignorant of the diseases which afflict us to-day as the present generation is of the epidemics of cholera and smallpox, malignant scarlet fever, etc., which were the terror of our forefathers." But scientific discoveries in nutrition would not be so rapidly effective were it not for advances made in other fields of social science. The Industrial Revolution brought in its train a gross indifference to darkness and to dirt, and an acceptance of conditions of human living which formed the basis of a pitiable nutrition. When the Romans invaded this country they brought with them certain ideals in cleanliness which were exemplified in the construction of famous baths. The Roman bath by a process of degeneration became in this country the public bath house, at first a most necessary if not entirely faultless institution, but with its passing there disappeared from England " an institution which filled a communal need for sweating, steaming, sociability and scandal ". Bad though the bath houses ultimately became they could not match the depravity of the gin houses of Hogarth Lane, that prototype of the most disreputable, depraved and degrading conditions of life in the early days of industrial expansion in this country. While such conditions have passed it could never

Europe.—In most European countries the situation shows a marked improvement; this is most significant in the increased consumption of calories and total and animal protein. The United Kingdom, the Scandinavian countries and Switzerland have an estimated energy and protein content of normal average food supplies per head which would indicate that they have no serious problem of malnutrition to contend with. In the bi-zonal area of Germany the intake of protein has risen definitely since the end of the war and is now 81 g. per head per day for total protein, 27 g. per head per day for animal protein, the total calorie intake being 2530 Calories per head per day. In the Soviet zone the figures are, total protein 68 g., animal protein 14 g., Calories 2410 per head per day; in Poland the total protein amounts to 74 g., animal protein 21 g., Calories 2620 per head per day; in Czecho-Slovakia the figures are, total protein 82 g., animal protein 32 g., Calories 2690 per head per day.

The Near East.—There is a relatively low supply of calories, animal protein and protective foods in the countries of the Near East. In many areas there is a marked insufficiency of milk and of fresh vegetables. Deficiency diseases are still widespread; infant mortality rates are still of the order of those found in the Far East and statistics, incomplete as they are, show that in general three quarters of the total calories are provided by cereals, starchy roots, tubers and sugars In Egypt, from the estimated energy and protein content of the food supplies, it is calculated that the energy intake is 2480 Calories per head per day, total protein 72 g. and animal protein 11 g. per head per day. In Turkey similar figures hold, the animal protein being somewhat less. That there is some improvement in the nutritional state of these countries is shown by the progressive diminution in the cases of pellagra, once a common deficiency disease both in Egypt and in Turkey. In Egypt considerable attention is being given to school meals and to the feeding of industrial workers in canteens.

India and Pakistan.—A great deal of highly scientific work on Indian diets has been carried out and has been well surveyed by Dr. Aykroyd (1941) and Dr. A. M. Thomson (1946). There can be no doubt as to the relationship between diet and the incidence of disease in India. The main dietary defects in India are too high a proportion of cereals, with accordingly a too

¶ For the warring countries as a whole, the acute shortage of foodstuffs and agricultural raw materials was alleviated by the excellent grain harvests of 1948 in the U.S.A. and Canada and by the greatly expanded agricultural production of these and other countries. After 1948 the acute need had passed and there was evidence in Europe and the U.S.S.R. that the agricultural war-damaged areas were rapidly recovering. A definite, but not so marked trend towards improvement was evident in other lands. The output of sugar, fats, fish, livestock products, fruits and vegetables had been enormously expanded, mostly in the temperate zone but also in tropical and sub-tropical zones. This improvement took place in countries which contained practically one quarter of the world's population; three quarters of the world's population therefore were little affected by these changes. It was clear after the war that people living in under-developed countries were worse off than previous to the war. There still remains a gulf in living standards between the rich and poor of such countries. While from statistical data it is clear that agricultural production in many under-developed countries has been recovering and expanding, and that in the Near and Far East many countries have approached their pre-war levels of production, important in considering this matter is its relation to the increase in population. In few of these countries has the per head food consumption been brought up to pre-war levels. If living standards are to be raised the increase in the production of food must be greater than the rate of population growth. The rate of growth of population varies from 1 per cent to 2·5 per cent per annum; it becomes necessary, therefore, that food production should be increased by at least 2 to 3·5 per cent per annum. According to recent reports of the Food and Agriculture Organisation, no plans have been made to meet this problem. It is true that the Technical Assistance Programme proposed by President Truman and accepted in principle by the Economic and Social Council of the United Nations will play a decisive part in dealing with these problems. It is therefore countries other than those of Western Europe and the North American continent which present the most difficult aspects of the problem of world malnutrition.

To-day, when judged by scientific standards, the diets of the great majority of the populations of eastern and tropical countries are still grossly deficient in many respects.

grains are concerned, and thus to become again a non-importer of cereals. In 1947–48 the quantity of cereals available for human consumption was 41·7 million tons, the imports during the year were 2·8 million tons, the total quantity therefore of food grains for 1947–48 being 44·5 million tons. For the year 1951, taking the increase in population into account, the total consumption is estimated to be of the order of 46·5 million tons. In dealing with this problem the government of India has addressed itself to the following schemes: the production and distribution of improved seeds; the application of chemical fertilizers and green manuring; the composting of farm-yard manure and town refuse and its application to the soil; the protection of plants from disease, pests and wild animals. The magnitude of the task may be more fully comprehended if one but recalls the large tracts of land awaiting reclamation; that wheat and rice suffer from diseases which cause severe and widespread damage to crops; that swarms of locusts and grasshoppers, winged and wingless, are an ever constant danger; that wild animals, which feed upon food grains, constitute a menace which cannot be adequately combated by government paid *shikaris* but require the active interest of farmers and agriculturists alike.

Food statistics for 1948–49 and 1949–50 show no significant improvement in the per-head supply of Calories and protein; for India the estimated Calorie intake per head per day for 1949 was 1620, total protein 42 g. and animal protein 6 g.; for Pakistan it was 2030 Calories, total protein 54 g., animal protein 13 g. per head per day. Attention has been and is being paid to the improvement of the nutritive value of rice by methods such as undermilling, parboiling and enrichment. Experiments in enrichment by means of the addition of thiamine, nicotinic acid and iron to rice have been carried out in the Philippines; it appears that such treatment of rice has led to a reduction in the incidence of beri-beri in children in India. A project to produce good quality soya bean milk and curd has been in operation for some time and while it shows soya products to be inferior to cow's milk in supplementing a rice diet, it indicates that for large rice eating communities soya products have certain definite economic advantages

The magnitude of the task of those who are responsible for the improvement of the nutritional state of the peoples of India and Pakistan has not been lessened by the aftermath of

great consumption of carbohydrates and a deficient intake of protein—particularly first class or animal protein—fats, minerals and vitamins. "India is a land of poverty in the midst of wealth, of social prejudices, irrational customs, and widespread ignorance." The presence of goitre, macrocytic anæmia, epidemic dropsy, beri-beri, amœbic dysentery and lathyrism can be largely attributed to dietary deficiencies. The use of milled rice which has been deprived of vitamin B_1 is an important factor. Parboiling rice is of value in that such treatment causes the diffusion inwards of the water-soluble vitamins from the outer layers of the grain. It is interesting to know that in the Provinces of Assam, Bihar, Orissa and Hyderabad 75 to 90 per cent of the rice-eating population consume it in the home-pounded state, which contrasts most favourably with the machine milling and polishing so common in other provinces, particularly Madras.

In the Indian sub-continent with its vast population of 400,000,000, a large proportion of the people, with respect to their dietaries, never approach physiological requirements. The Hindu population is largely vegetarian, the higher castes rigidly so; the only animal protein they consume is in milk. Moslems and Sikhs have a much better supply of animal protein in that they eat certain meats, fish and eggs, in addition to whole grains, vegetables and fruit. Deficiency diseases such as keratomalacia, the commonest cause of blindness in Southern India, beri-beri, osteomalacia in women, due not only to food deficiency but to the social custom of purdah, create major public health problems in certain areas. In India 50 per cent of the total mortality occurs in children under ten years of age, that is five times greater than in the West. Probably the most important advances which could take place in India would be to increase dairy farming and place agriculture on a sound scientific basis.

Before the war India was an importer of rice, mainly from Burma; the problem of food supply both for India and Pakistan as also for the States is to-day one of producing sufficient food to maintain the minimal nutritional standards throughout the country. The Bengal famine in 1943 showed how acute the problem of feeding the people could be and led to the "Grow More Food" campaign by which the Government of India plan to bring the country to a state of self sufficiency as far as bread

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Africa.—In tropical Africa there is abundant evidence of malnutrition and deficiency disease, which is true of all tropical areas. Little or no milk, a low meat consumption and an excessive starch diet mean a lack of body-building proteins, mineral salts, vitamins and fats, all so essential if the human body is to approach its maximal or optimal efficiency. Estimation of the nutritional state of the peoples of Africa is almost impossible because of the diversity of racial and economic groups. There are widespread inequalities in food distribution and one can arrive at no national average nor can one give a satisfactory picture of the actual consumption of foodstuffs. There is still widespread malnutrition amongst the native tribes, as also in the Reservations. The infantile death rate from starvation and deficiency diseases is still a matter of concern. While one can find some excellent specimens of African natives, e g. Zulus and meat-eating Masai, they are a small minority.

Latin America.—The problems of nutrition are being attentively studied by the International Labour Office with the aim of framing a common policy on nutrition for adoption by the different States of South America. The situation varies greatly in the States of Latin America, being in general terms most satisfactory in Argentina, and least so in Chile and Peru For example, in Argentina and Uruguay there is a fairly good consumption of meat, milk, milk products, eggs and butter. In these countries cattle outnumber people and meat consumption is probably among the highest in the world. On the other hand, in Chile where meat and milk are relatively scarce, the total protein intake is 71 g , while the animal protein intake is as small as 23 g. per head per day. It is stated that the unit of meat consumption is twice as high in Argentina as in any other country in the South American continent In Colombia the situation is not so favourable, the total protein intake being 56 g. compared with 102 g. per head per day in Argentina; the consumption of animal protein in Colombia is about 26 g. per head per day compared with 66 g. per head per day in Argentina.

partition, with its travail and sorrow, and millions of hungry, diseased and shelterless refugees, to which, unfortunately, have been added the unpredictable effects of famine, earthquake and flood.

China.—In China there is unfortunately widespread malnutrition. The high incidence of tuberculosis and rickets, the low resistance to infectious disease, the high infantile death-rate and the heavy parasitic infestation of the people are evidence of a very low nutritional state. As in India so in China, the development of dairy farming would be a great step forward Chinese diets are characterized by a preponderance of cereals, a low percentage of animal protein and a lack of milk. This is indicated by the energy and protein content of available foods which supplied for 1947–48 2120 Calories, total protein 68 g, animal protein 4 g. per head per day. Among the staple foods rice forms the major part of the diet in the south, while in the north, wheat and kaoliang, as well as rice, are eaten. As a result of these differences in the consumption of polished rice there is a greater incidence of beri-beri in the south compared with that which obtains in the north of China. Other cereals are millet and maize, of which large amounts are eaten.

On the coast, however, the situation is better because fish and other seafoods are available as sources of animal protein. Fish, which in certain parts of China is eaten raw, contains thiaminase, an anti-vitamin B_1 enzyme; this may in part be responsible for the vitamin B_1 deficiencies so common in Southern China.

Although, previous to the war, China was one of the most important egg exporting countries, yet even in families of well-to-do farmers in North China, where the consumption of eggs is highest, the average consumption does not approach one egg per head per week. Milk consumption is negligible, and there is considerable prejudice against its use. Dr. H. C. Hou, of the Institute of Nutrition in Nanking, suggests that the food supply of China could be improved by the following means: promoting pig rearing as an industry; developing the processing of soya beans as a source of protein food; increasing the supply and transportation of fish so that people living in the interior of China may obtain more of a very valuable food; parboiling and enriching rice to ensure a higher content of the vitamin B complex. In the nutritional interests of the people, much

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energy source and are accompanied in the dietary by a sufficiency of meat, sugar and fat, they play their correct rôle, particularly the whole grains, as excellent sources of vitamins and mineral salts. But when they bulk too largely in the diet they are evidence of a low standard of living and an inability to obtain or to purchase other necessary foods.

THE POSITION OF CEREALS AND POTATOES IN HUMAN DIETS (BENNETT, 1941)

Percentage Calories from Cereals and Potatoes	Countries	Total Population, Millions
30 to 40	U S A , U K , Canada, New Zealand, Switzerland, Sweden, Austria	205
40 to 50	Germany, Denmark, Holland, Norway, Australia	93
50 to 60	Eire, France, Belgium, Baltic States, Czechoslovakia, Argentina	93
60 to 70	Portugal, Spain, Italy, South and Central America	204
70 to 80	Poland, Bulgaria, Yugoslavia, Egypt, Japan, Algeria, Tunis	156
80 to 90	Roumania, China, India, rest of Africa, Russia (position not accurately known)	1344
	Total	2095

The world population to-day is approximately 2,350 millions (F A.O 1950)

Rice.—In India, China, Japan and the East Indies some 87,000,000 tons of rice were produced in 1936. This is the staple diet of some 700 to 800 million people and only two million tons were exported, mainly to European countries. This means that on an average 0·75 lb. of rice is consumed per head daily and this provides approximately 1340 Calories. The staple diet provides about half the energy which we would expect would be expended by the average peasant. That there is a deficiency in Calories and nutrients one can well understand. It has truly been said of India that "there are always three mouths for every two rice bowls".

Sugar.—As a further example of uneven distribution due to the competitive trends in world trade we may take the production and consumption of sugar. In 1936, the great sugar producing centres, the Carribean and the East Indies,

calcium to the diet. In other Central American countries where maize is eaten this practice is not followed, with the result that there is a definite calcium deficiency.

THE UNEQUAL DISTRIBUTION OF FOOD

Milk.—Over a decade ago the liquid milk equivalent, that is, milk in all forms and its products, cheese and butter, consumed in Britain amounted to about 700 pints per head per year. In U.S.A. approximately the same amount was consumed. In New Zealand and in Switzerland the consumption was about 1000 pints per head per year. But pre-war figures show that the average consumption was in Poland, about 400 pints; in Italy, 183 pints per head per year. If we accept the decisions of nutrition experts with regard to the amount of milk and milk products which should be consumed, then in Britain the amount should be increased by at least 30 per cent. As one passes from the pre-war favoured nations of Europe and America to South-east Europe, South America, Africa and China, the unequal distribution is all too apparent. As to China, Africa and India the figures are only approximations but one can say that the Chinese coolie who gets one half of a pint of milk per week is well off. In India one need only see the quality of the milk, and note the almost negligible amounts used, to realize how pitiably lacking in this valuable article of diet the Eastern peoples are and how totally inadequate would be even a 200 per cent increase in milk production. The story is almost the same for eggs and butter, and the unfortunate fact to be faced is, that an immediate increase in dairy products in Asiatic countries is almost out of the question. Still these facts remain as an indicator of the dire need of these people.

Cereals.—A similar situation obtains with regard to cereals upon which most of the world's population depends for the major part of its supplies of human energy. The energy foods, so called because of their large starch or sugar content, are rice, wheat, maize, oats, rye and potatoes.

Some interesting facts emerge when one considers the pre-war production and consumption of cereals and potatoes (Bennett, 1941).

It is clear that the use of cereals must not be regarded lightly. When they form approximately 40 per cent of the

fruit and dairy products. There is no reason why a very fair proportion of this relatively small surplus of food should not pass to the Balkans, South America and China.

"Yet it only requires to raise the effective demand in China by 10 per cent to make China a competitive importer of Javanese sugar, Australian beef and New Zealand butter."

It is necessary to grasp the fact that a number of the food exporting countries reject their foodstuffs, not because their population is already overfed, but because they need to purchase raw materials, textiles or machinery. In some instances, as with Burma, Cuba and Jamaica, they have neglected stock-raising and vegetable culture for their own subsistence in favour of the mono-culture of rice or sugar or bananas. Under a more wholesome economy they would divert some of their labour to the adequate feeding of their own people. At the other extreme there are perhaps five or six exporting countries who could in the immediate pre-war years boast that they still retained within their borders a sufficiency of food for the whole population; these true surplus exporting countries are Denmark, Canada, Australia, New Zealand and possibly Argentina and Uruguay. Even in these countries the diet of the poorer classes often leaves much to be desired. As for the small food exporting countries represented by Algiers, Turkey and South Africa, it is doubtful how far they would remain on the world market if they so adapted their economy as to provide first for the needs of their own inhabitants.

The situation with regard to inequalities in world food distribution as they obtain today is clearly set forth in the Survey of World Conditions published by the Food and Agriculture Organisation. Previous to the war 22 per cent of the total world population had available food giving less than 2000 Calories per head per day; to-day the proportion is 35 per cent. Previous to the war half the world population had a Calorie level of about 2240 Calories per head per day as compared with 2120 Calories per head per day in 1950. The aggregate calorie supply for all countries increased by less than 1 per cent, so that with an 8 per cent increase in population from 1938 to 1948, the per-head average is lower than the pre-war average by about 7 per cent, that is, 2220 [illegible]

With regard to

than 80 per cent

placed some 6,000,000 tons of sugar on the world market. In that year Britain and the U.S.A. consumed 5,000,000 tons! These two countries contain one-tenth of the population of the world and they utilized 83 per cent of world sugar production! And the tale is the same for fruit, oils and fats; the favoured peoples, those of the North American continent, the British Commonwealth of Nations and the Western countries of Europe with the exception of Spain and Portugal have, or rather had, previous to the war of 1939–45, full control of the world's markets.

There are several factors which prevent an even distribution of food and are therefore productive of a bad world nutritional status. Some of them are fear of, or the desire for, aggression, leading to the uneconomic employment of human and natural resources, the expenditure of large sums of money on armaments, and the creation of barriers to international trade. Freedom from want may certainly be the forerunner of freedom from the fear of war and economic insecurity. In our generation the world has been obsessed by fear, fear of aggression, fear of social and economic insecurity. When in the future the fear of military aggression has gone, progress towards the goal of the four freedoms will be retarded if a spirit of opportunism in political and economic life is permitted full sway. To plan successfully for the removal of world malnutrition, certain unpalatable facts must be faced by the favoured nations of the world, particularly the British and the American. The difficulties of the problem for heavily importing countries have been clearly set out by Mr. Le Gros Clark from whose paper, " Hotsprings and Humanity ", the following is quoted:

" With the exception of the United States, all meat, butter, and fruit exporting countries have small populations. Several of them have a fairly high level of consumption of the foodstuffs in which they deal. But the main importing countries also cover between them a very small percentage of the world's population. Omitting the United States, which only enters the market significantly for sugar, vegetable oils and some fruits, we find that a large proportion of the overseas trade in foodstuffs is diverted to about 7 per cent of the world's consuming public. Thus, some 10 per cent to 15 per cent of the world's population appear to be engaged in distributing among themselves the large bulk of the annual reserves of meat, sugar,

The aggregate supply of milk products represents a gain from pre-war of about 6 per cent, which is almost as much as the gain in population, namely 8 per cent.

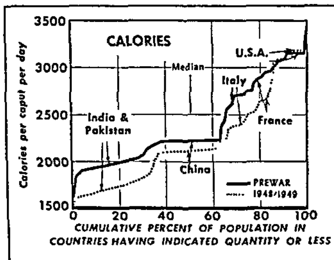


FIG. 1

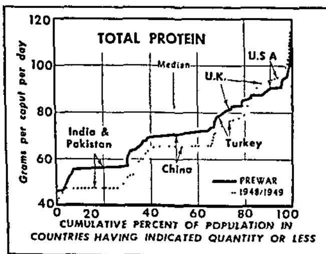


FIG. 2.

pre-war period. This is due to a reduction in the supplies of animal foods and grains. The countries which are within the remaining 20 per cent of world population and have more total protein than before the war are the U.S.A. and Canada, indeed the only countries which have more than 85 g. of total protein per head per day are Australia, New Zealand, U.S.A., Canada, and in Europe, Denmark, Finland, Ireland, Norway, Sweden, the United Kingdom and Switzerland. While the aggregate supply of total protein for world populations has increased about 2 per cent, nevertheless with the increase of population since the war the per-head average shows a decrease of about 7 per cent (Fig 2).

The changes in animal protein supplies are more significant and more serious than those in total protein; the changes naturally are much smaller, but 50 per cent of the world population receives, in terms of food supplied, about 8 g. per head per day. The unfavoured peoples are in China, India, Pakistan and Indonesia. For most peoples, apart from those of the North American continent, there has been a slight fall in supplies of animal protein. The average intake per head of world population to-day is about 18·5 g. as against 19·6 g. per head per day before the war, that is a drop of 6 per cent. The favoured nations in respect of animal protein are Australia, New Zealand, Canada, U.S.A., Argentina, Uruguay, Denmark and Sweden, all of which receive 60 g. or more of animal protein per head per day. The great lack of animal protein is to be found mainly in the Far East, the Near East, in North and Central Africa and the Latin American countries with the exceptions already mentioned (Fig. 3).

The position for milk products, in terms of fluid milk equivalent, shows a similar sharp contrast between the most favoured and the least favoured countries. The world distribution of milk products shown in Fig. 4 in terms of the fluid milk equivalent, is based on the grams of milk (3.5 per cent protein) which would provide as much protein as the total of all dairy products consumed. (Chatfield, Scott and Mayer, 1950.) Before the war 50 per cent of the world population received less than 200 g. per head per day, in contrast to the present level of 165 g. per head per day or less; to-day some 70 per cent of the world popula-

These facts simply corroborate what has already been said, namely that the favoured nations show significant improvement since the war, the unfavoured nations seem to have deteriorated. The over-all food supplies still remain for them grossly inadequate and the inequalities in distribution have become greater.

From experience gained in this country during the war, it becomes evident that the chief measures which should be [illegible]

peoples; enrichment, by the addition of minerals such as calcium to the bread grains and vitamins to staple foods; supplementary feeding, whereby nutritional deficiencies with respect to vulnerable groups can be made good; and educational programmes, whereby children and adults are instructed in the nutritive values of various foodstuffs.

Planning for an Equitable World Food Distribution.—Planning for the abolition of world malnutrition demands the closest collaboration of nutrition, public health and agricultural authorities. This collaboration, varying from purely scientific research to the intricacies of economic readjustments, must be on an international scale. Planning for the greater production and better distribution of food, which should be considered with other forms of production and trade, must be based on modern scientific knowledge of human dietary requirements. Since we know the requirements, we can determine the needs of a population for health in terms of the more important nutrients; and since we know where the dietary need is greatest, we can plan for the necessary production and equitable distribution of adequate food supplies. The great variety of the foods of the world can be classified into cereals, milk, eggs, butter and fats, meats, vegetables and sugar. The determination of the absolute amounts of the more important nutrients requires a knowledge of the distribution of infants, children, pregnant and nursing women and occupational groups within the population, and a translation of their nutritional requirements into terms of foods. It also requires that certain essential foods and supplements be made available for the vulnerable groups, i.e. infants, children, nursing mothers, invalids and the aged. It is also necessary to secure data concerning the amount of

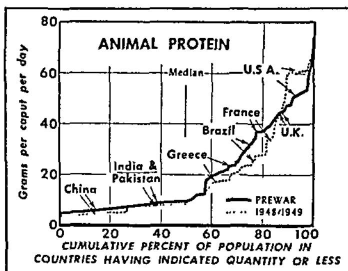


FIG. 3

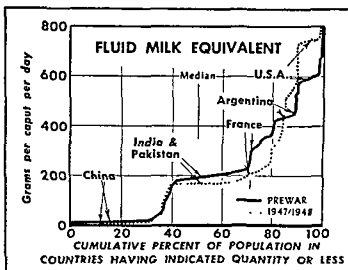


FIG 4

Figures 1-4 are reproduced from *Food and Agriculture · World Conditions and Prospects*, Washington, D C , U S A , 1949 [*By courtesy of Dr. Aykroyd, Nutrition Division, Food and Agriculture Organisation*

education. Only by such preparation can we hope to promote technical efficiency in what we would hope will continue to be large farming communities and to develop a better understanding of rural problems. It has been definitely stated that each nation should adopt a policy of promoting research in all branches of science including economics which relate to food and agriculture. Nothing should be left undone which would promote research in the natural sciences and apply the scientific method to the numerous problems of food and agriculture.

This is but a brief survey of the situation and of the difficulties which will attend the realization of a greater freedom from want. The task is enormous and will demand goodwill, compromise and vision on the part of statesmen of all nations. The task is nothing less than that of harnessing social and political security to human welfare ; its success may well prove to be the very basis of world peace.

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food produced within, and also the amount imported into, a country. Following upon the decisions as to the accepted balance between home produced and imported food will come one of the main parts of the whole problem, namely to make it possible for all consumers to secure an adequate and suitable supply of food. If these fundamental points be applied to all nations it will readily be recognized how this problem of world malnutrition will depend for its solution on a world wide policy of expansion and, if necessary, a reorientation of industry and agriculture. This is where the task passes from the nutritional aspect into the wide and extremely difficult sphere of international or world economics.

At the United Nations Conference on Food and Agriculture (1943) it was recommended amongst many other things as a long-term production policy :—

(1) " that the inherent natural and economic advantages of any area should determine the farming systems to be adopted and the commodities to be produced ;

(2) " that each nation should direct its own policies towards increasing efficiency of production, encouraging the production of foods which are high in vitamins but relatively perishable, e g. vegetables, fruits, milk, eggs and meat, and limiting the production of bulky, easily stored and transported energy foods ;

(3) " that to implement these aims, measures should be adopted to help producers to acquire materials, equipment and machinery and, equally important, to secure technical assistance ;

(4) " that for the immediate and successful solution of the new problems of agriculture, steps should be taken to develop education and research. It was recommended that each country should strengthen and expand the educational system of its rural areas, train scientific workers and rural leaders for service in agriculture, and that each nation should adopt a policy of promoting research in all branches of science, including economics, which relate to food and agriculture."

The inadequacy, in many countries, of agricultural education and of research facilities is well known. If the people who live on the soil are to benefit by their work they must know the soil, and therefore it is most important that there be some strengthening and expanding of education in rural areas. Not only must there be a sound introduction to biological knowledge in secondary schools but an increase in facilities for rural adult

recent nutritional scientific knowledge could best be applied to the feeding of the people. In its work this Committee had before it the Report on the Physiological Bases of Nutrition issued by the Health Committee of the League of Nations in 1936. Briefly, the conclusions of this important Committee in 1937 were: that in the *national food supply* there was no lack of energy-giving foods, carbohydrates, fats and proteins, but there existed a small section of the people who did not obtain adequate supplies of these, that is to say, there was a faulty distribution of essential foods.

The most significant finding was, however, with regard to milk. Taking the League of Nations recommendations as to human requirements, emphasizing the nutritional importance of milk, particularly for mothers, children and adolescents, the Advisory Committee stated that, "the present national consumption of liquid milk is less than one half of" the required amount, namely seven-eighths of a pint. If condensed and dried milk were also included, the national consumption was only 60 per cent of the amount suggested by the League of Nations Commission.

A comparison of the consumption per head per week of certain foods in the periods 1909–13, 1924–28, 1934–35, 1937–38, indicates how, despite marked deficiencies in food distribution, there has been a steady improvement in dietaries, an improvement which has resulted largely from the educational work carried out in schools and in health clinics, and particularly by means of the important publications issued by the health and education departments of the Government

The general steady upward trends in food consumption are shown in Table 1.

In view of what has been stated about unequal distribution of food, and having regard to the significance of rationing during the 1939–45 war, it is of interest to note the foods which have come into greater consumption between 1909 and 1938. It will be noted that there has been a steady and, in some cases, a marked increase in the consumption of certain foods; they are eggs, fruit and vegetabl[illegible] The foods, the [illegible] with income, [illegible] and the most important for health, namely, eggs, fruit and vegetables, butter, fresh milk and meat.

CHAPTER III

THE PROBLEM OF NUTRITION IN GREAT BRITAIN

THE FOOD SITUATION, 1914 TO 1938

By the end of the nineteenth century the battle for cheap food had been won, and in some measure, at the expense of agriculture in this country. While it could be said, in general terms, that the population of the United Kingdom did not suffer from hunger, there was still a large minority of the people who certainly did not secure an adequate diet. The impetus given to research in nutrition by the discovery of vitamins led to a practical consideration of the nutritional status of the people. The older conception of an adequate diet, namely that it must supply a sufficiency of calories and satisfy hunger, had given place to a consideration of quality translated into terms of nutrients necessary, not only for energy, but for the building of a structurally sound body. The newer knowledge of nutrition had, in brief, demanded new and more refined dietary standards. No longer was it a question of Calories and protein but of Calories, protein, vitamins, mineral salts and water. In the interim war period so decisive was the impact of this new knowledge upon the official mind that in 1931 a small committee of physiologists was appointed by the Minister of Health and the Secretary of State for Scotland to advise the Minister of Health " on the practical application of modern advances in the knowledge of nutrition ". Apparently impressed by the findings of this body, the same authorities, in 1935, appointed an Advisory Committee on Nutrition " to enquire into the facts, quantitative and qualitative, in relation to the diet of the people and to report as to any changes therein which appear desirable in the light of modern advances in the knowledge of nutrition ". This called for an investigation of the amounts of the various foods consumed by men, women and children of this country, an opinion as to the adequacy or inadequacy of the national dietary, and suggestions as to the means whereby

Table 2 represents a limited survey in a population of over 45,000,000 people. If data from very extended surveys covering all classes of the community were available, in which the average consumption of each foodstuff in each group, duly weighted in terms of population and man value of the families in these groups, it may be possible, given perfect statistical efforts, to expect a close agreement between the results so obtained and the figures representing the national average consumption of these foods obtained by dividing total supply by total population. This, however, is beyond the bounds of present possibility, because of inherent errors in both methods. Perfection in dietary surveys cannot be attained, if indeed it could be expected, even if carried out continuously throughout the year, for not only must climatic or seasonal changes be investigated, urban and rural populations be separately surveyed, but within these populations account must be taken of the sedentary, the manual and the heavy industrial worker and, with the numerous family groups, a further differentiation must be made between infants, children, adolescents, women, nursing mothers and old people. To expect a precise answer to the amount of food consumed per head per week of the population by determining the total food supplied to the people, is to ignore many factors, such as waste in transport, storage and delivery, which militate against any high degree of accuracy. Such difficulties and such criticisms do not in the least detract from the value of this important work, for despite all difficulties and all criticisms, such surveys have given in the past, and during the recent war, a remarkably clear indication of the food habits of the various communities which collectively make up the nation, and have pointed the way to the correct control of the nation's food supply.

THE IMPACT OF WAR ON THE PROBLEM OF NATIONAL NUTRITION

It is an oft-repeated statement that it has required a world war to show us how to grapple with the problem of feeding the nation. To feed a nation properly, simply means to make available to all classes of the people a diet adequate to keep them in a fit state of health, and this means that energy foods must be available to enable heavy workers to perform the various

As a result of numerous dietary surveys in Britain, Australia, New Zealand, U.S.A. and the continent of Europe, it has been shown that in the 1930–35 period varying percentages of the people in the countries investigated suffered from an inadequacy of food supply. It has been shown by Sir John Orr, now Lord Boyd-Orr, in his book, *Food, Health and Income*, published in 1936, that in the United Kingdom 30 per cent of the people did

TABLE I

FOODS CONSUMED PER HEAD PER WEEK UNITED KINGDOM

From the First Report by the Advisory Committee on Nutrition, 1937, and from *Feeding the People in War-time*, by Sir J. B Orr, F R S, and D. Lubbock, 1940

	1909–13	1924–28	1934–35	1937–38
	lb.	lb.	lb.	lb.
Meat, including poultry	2 58	2 56	2 81	2 62
	pints	pints	pints	pints
Milk and cream .	3 46	3 35	3 20	3 85
Condensed milk .	*0 05*	*0 14*	*0 23*	
Eggs in shell . . .	1 93	2 34	2 90	4 48
	lb.	lb.	lb.	lb.
Butter	0 30	0 31	0 49	0 43
Margarine . .	0 11	0 23	0 15	0 30
Cheese .	0 14	0 18	0 19	0 18
Lard	0 08	0 11	0 18	—
Fish	0 79	0 80	0 87	0 87
Sugar	1 52	1 60	1 79	—
Cereals (+ wheat and flour) .	4 45	4 41	4 04	4 06
Potatoes .	4 68	4 43	4 25	4 24
Other vegetables	1 38	1 81	2 22	3 9
Fruit	1 19	1 75	2 23	—
Tea .	0 12	0 17	0 18	—

not receive that amount of food necessary for the supply of required amounts of protein, certain vitamins and minerals; if calcium requirement were the only standard by which diets are to be judged, then some 50 per cent of the population was deficient in this respect. Such findings were corroborated generally by the results of the survey made by Sir William Crawford in 1936–37. Pertinent to the present discussion is the amount of the important foods consumed by the six income groups into which the population was divided by Lord Boyd-Orr.

Bread and flour (including biscuits and cakes) (b)	ozs	66 0	68 0	68 0	67 0	65 0	60 0	66 0	61 0
Milk, fresh	pints	1 1	2 1	2 6	3 1	4 2	5 5	3 1	2 8
,, condensed (c)	,,	0 7	0 6	0 55	0 5	0 4	0 3	0 5	0 5
Eggs	No	1 5	2 1	2 6	3 2	3 6	4 5	2 9	2 9
Butter	ozs	3 0	6 5	7 5	8 5	9 5	11 0	7 8	7 8
Cheese	,,	1 8	2 5	3 1	3 6	3 6	2 6	3 0	3 2
Margarine	,,	4 5	3 5	2 5	2 0	1 6	1 3	2 5	2 4
Tea	,,	2 2	2 7	2 9	3 0	2 9	2 7	2 8	2 8
Potatoes	,,	53 0	56 0	57 0	57 0	57 0	54 0	56 0	61 0 (d)
Lard, suet and dripping	,,	2 7	3 6	4 2	4 4	4 3	3 5	3 9	2 7 (e)
Fish	,,	2 7	5 5	8 2	10 4	12 2	13 5	8 9	13 2 (a)
Sugar purchased as such	,,	13 5	16 0	18 0	19 0	19 5	19 5	17 8	27 7 (g)
Jams, jellies, syrup, etc	,,	4 3	5 3	5 2	5 4	5 8	5 5	5 2	(h)
Sugar consumed in other forms	,,	6 5	7 5	8 5	9 5	10 5	11 5	9 0	(i)
Fruit (k)	,,	14 0	21 7	25 8	27 9	30 5	39 3	26 5	35 1 (j)
Vegetables (excluding potatoes) (k)	,,	16 0	20 0	27 2	30 6	32 3	34 0	27 0	30 2 (f)

(a) Includes wastage in distribution

(b) In terms of flour. 130 bread = 100 flour

(c) In terms of liquid milk equivalent. Allowance has been made for consumption of condensed milk in complex foodstuffs

(d) Includes allotment production

(e) Lard only.

(f) Includes shop wastage estimated at 10 per cent

(g) Includes industrial consumption estimated at 40 per cent.

(h) Included in fruit and sugar

(i) Included in sugar above

(j) Includes fruit used industrially estimated at 25 per cent.

(k) Group quantities for fruit and vegetables have been estimated from expenditure after allowing for quality variations, but the figures are subject to a wide margin of error

TABLE 2

QUANTITIES OF FOOD CONSUMED PER HEAD PER WEEK AT DIFFERENT INCOME LEVELS IN 1152 FAMILY BUDGETS

From *Food, Health and Income*, by Sir J B Orr, F R S , 1936

	Group I	Group II	Group III	Group IV	Group V	Group VI	Weighted Average of Groups	National Average
Proportion of the population .	10 %	20 %	20 %	20 %	20 %	10 %	—	—
Number of persons in the group millions	4 5	9	9	9	9	4 5	—	—
Number of budgets . .	411	152	233	156	136	64	—	—
Average income per head per week .	up to 10s	10s to 15s.	15s *to 20s*	20s *to 30s*	30s *to 40s.*	over 45s	30s	—
Average food expenditure per head per week . .	4s	6s	8s	10s	12s	14s.	9s.	—
Beef and veal . ozs.	10 5	14 5	17 2	18 9	19 5	18 9	17 0	20 0 (*a*)
Mutton and lamb . . ,,	3 1	5 6	7 2	9 4	11 6	13 9	8 4	9 0 (*a*)
Bacon and ham . ,,	4 3	6 3	6 8	7 3	7 8	9 4	7 0	7 8 (*a*)
Other meat . . ,,	5 2	5 2	5 9	5 9	5 9	7 2	5 8	7 2 (*a*)
Total meat . . ,,	23 1	31 6	37 1	41 5	44 8	49 4	38 2	44 3 (*a*)

a greater dilution of wheat flour. Home production was increased from 1·6 million tons in 1914 to 2·4 million tons in 1918. From a 76 per cent extraction in 1916, wheat extraction was raised to 90 per cent in 1918. For the purpose of diluting wheat flour, barley, rice, oats, maize, potato flour and even beans were used. From 1917 to 1918 dilution ranged from 15 to 30 per cent; the latter figure was an extreme limit which lasted but for a few months in 1918. The result of these methods was a 54 per cent increase in the amount of flour produced in 1918, extraction being responsible for 25 per cent and dilution for 29 per cent of the increase. The price of bread was also controlled by subsidy which amounted to £50,000,000 sterling per annum for three years.

Sugar, the first of all the foodstuffs to be controlled, was the special care of a Royal Commission from 1914 to 1918, and thereafter the supply was controlled by the American Food Administration. Before the war and before the control from the 1st January 1918, the amount of sugar consumed by the people of this country was approximately ¾ lb per head per week. With rationing the amount was never less than 8 oz per head per week. Despite labour shortage and bad weather, the potato crop was increased in 1918 by 20 per cent over pre-war figures, due to an almost 30 per cent increase in acreage. Carbohydrates were therefore well cared for during the first world war.

Because of the long sea lanes across which our meat has to be transported, it is not surprising that with 40 per cent of our meat imported and half of that from Argentina, the supply and therefore the consumption of meat fell in 1917 by 31 per cent of the pre-war figure of 1912–13. The imports of mutton and lamb from Australia and New Zealand suffered most. The ploughing up of grass lands and the scarcity of feeding stuffs for fattening animals were additional factors causing this marked fall in meat supply. This was the legitimate result also of the policy recommended by the Food (War) Committee of the Royal Society. Home produced meat was maintained at pre-war levels until the end of 1917, when, due to the causes mentioned, it fell in 1918 by about 33 per cent of the pre-war figure. Lack of supplies, high prices, and bad distribution forced the Ministry of Food to undertake the control of meat supply by rationing, which was instituted in 1918 and was not stopped until December 1919.

duties to which they may be called, and that protective foods must be made available to the vulnerable groups; these are infants, children, adolescents, pregnant women and nursing mothers.

When a country such as ours faces as it did in 1915, and even more seriously in 1940, a submarine menace calculated to cut off all imported foods, its Government has to take steps immediately to increase to the maximum the home production of food.

The War of 1914-18.—During the first two years of the 1914–18 war there was little change in the food supply, but when by the close of 1916 Britain had lost 2,000,000 tons of shipping out of a total of 17,000,000 tons and had only a third of the tonnage available for the transport of food, then regulations were enacted to ensure the increased production, importation and equable distribution of vital foodstuffs. It was not until 1917 that Lord Rhondda, as Food Controller, fixed maximum prices for certain foods for producers and retailers and also controlled the distribution of essential home produced and imported food supplies. The first foodstuff to be controlled by rationing at 8 oz. per head per week was sugar. Other foods, such as butter and margarine, were not controlled until considerable hardship, caused by unfair distribution, roused local authorities to arrange, through Local Food Committees, schemes of public distribution. It was not until 1918 that rationing was made compulsory throughout the United Kingdom. It was a long, tedious and at times anxious experiment in food control, the results of which proved of great value when we were again faced with the vital task of feeding the nation in time of war. The details of the experimental procedure during the war of 1914–18 are given in *Food Production in War*, by Sir Thomas Middleton and in *Food and Planning*, by Professor J. R. Marrack. In essentials the food control policy was based on the control of bread, sugar, meat and milk. In 1916 a Wheat Commission was responsible for carrying out the bread policy of the Government. For scientific advice the Commission had the services of the Food (War) Committee of the Royal Society, a group of physiologists, biochemists, statisticians and agriculturists. The policy of the Government demanded three things, namely; a greater home production of wheat, a higher extraction of the wheat berry and

a greater dilution of wheat flour. Home production was increased from 1·6 million tons in 1914 to 2·4 million tons in 1918. From a 76 per cent extraction in 1916, wheat extraction was raised to 90 per cent in 1918. For the purpose of diluting wheat flour, barley, rice, oats, maize, potato flour and even beans were used. From 1917 to 1918 dilution ranged from 15 to 30 per cent; the latter figure was an extreme limit which lasted but for a few months in 1918. The result of these methods was a 54 per cent increase in the amount of flour produced in 1918, extraction being responsible for 25 per cent and dilution for 29 per cent of the increase. The price of bread was also controlled by subsidy which amounted to £50,000,000 sterling per annum for three years.

Sugar, the first of all the foodstuffs to be controlled, was the special care of a Royal Commission from 1914 to 1918, and thereafter the supply was controlled by the American Food Administration Before the war and before the control from the 1st January 1918, the amount of sugar consumed by the people of this country was approximately ¾ lb. per head per week. With rationing the amount was never less than 8 oz. per head per week. Despite labour shortage and bad weather, the potato crop was increased in 1918 by 20 per cent over pre-war figures, due to an almost 30 per cent increase in acreage. Carbohydrates were therefore well cared for during the first world war.

Because of the long sea lanes across which our meat has to be transported, it is not surprising that with 40 per cent of our meat imported and half of that from Argentina, the supply and therefore the consumption of meat fell in 1917 by 31 per cent of the pre-war figure of 1912–13. The imports of mutton and lamb from Australia and New Zealand suffered most. The ploughing up of grass lands and the scarcity of feeding stuffs for fattening animals were additional factors causing this marked fall in meat supply. This was the legitimate result also of the policy recommended by the Food (War) Committee of the Royal Society. Home produced meat was maintained at pre-war levels until the end of 1917, when, due [illegible] 1918 by about 33 per cent [illegible] supplies, high prices, and [illegible] of Food to undertake the control of meat supply by rationing, which was instituted in 1918 and was not stopped until December 1919.

duties to which they may be called, and that protective foods must be made available to the vulnerable groups; these are infants, children, adolescents, pregnant women and nursing mothers.

When a country such as ours faces as it did in 1915, and even more seriously in 1940, a submarine menace calculated to cut off all imported foods, its Government has to take steps immediately to increase to the maximum the home production of food.

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had not the accuracy of those of the present day, it is clear from dietary surveys that there must have been a deficiency in vitamins A and D. The anti-scorbutic vitamin C probably suffered the same vicissitudes as it has done from 1940 to 1945 In view of present-day knowledge, it could not have reached satisfactory levels. Viewing the situation as a whole, one may safely conclude that the initiation of food control was too long delayed and that the success of the rationing schemes was largely due to the fact that bread rationing had been avoided. It was this that enabled the country to face with fortitude the serious dangers of March and April 1918 A year before, errors made by the Germans in estimating the harvest yields, and a failure to control strictly all rationing, showed the world how quickly "the will to win" can give place to a demand for "peace at any price".

Those especially concerned with the food problem realized, if others did not, that the home front was as important as any other front. The future, unfortunately, was destined to give further corroboration of this fact.

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Bacon and ham are extremely valuable foods, giving a very high Calorie value. Two-thirds of these foodstuffs were imported, about 60 per cent coming from Canada and U.S.A., but these imports rose above the 1913 level by 40 per cent in 1915 and 60 per cent in 1916, fell a little in 1917 and rose again in 1918 to 100 per cent of the 1913 figure.

In view of the importance of the supply of *liquid milk* in the 1939–45 war, it is of interest to note briefly the changes in milk supply during 1914–18. No great change occurred in the number of cows but the supply of fresh milk fell some 15 per cent in 1917 to 25 per cent in 1918. Dried milk, of which previously only small amounts were produced at home, was so greatly increased that, in 1917, as much was home produced *as had previously been imported, and by the end of 1918 that* amount had been doubled. As a result of high prices (5d. per pint) the poorest income groups did not obtain adequate supplies, and ultimately, by the Milk (Mothers and Children) Order, (February 1919) local authorities were empowered to supply milk free to children under 5 years of age and to pregnant women. This was a permissive regulation and, like many, if not most non-enforced laws and regulations, was very unsatisfactory.

Butter and margarine showed interesting changes in supply and consumption. In 1913 the consumption of butter was 4·9 oz., that of margarine 1·76 oz. per head per week. In view of the large amount of butter imported, approximately 90 per cent before the war, a fall of 50 per cent in consumption by 1917 was not altogether unexpected. Margarine, of which about half was imported, continued to be imported until 1918, when it was stopped, the importation having fallen rapidly in 1917. Home production was, however, greatly increased, so that in 1918 the consumption had risen from the 1913 figure of 1·76 oz. to approximately 3·50 oz. per head per week. The doubling of the margarine consumption, which at that time contained no vitamin A, offset to some extent the loss in energy value due to the fall in consumption of sugar and butter. Total Calories *fell but little—about 4 per cent.* The greatest loss was in animal protein which reached the low unsatisfactory level of 25 grams per head per day. Total protein, viewed from the present-day standard, was low at an average of 69 grams per head per day. While during 1914–18, methods for the estimation of vitamins

designed to place this nation in a food position strong enough to face, with some degree of equanimity, the appalling danger into which it was soon to be placed by a ruthless submarine campaign. The magnitude of the problem can be seen from Table 3 which shows the extent to which we were dependent upon imported foodstuffs; for flour, fats, sugar and cheese we were dependent upon importation to a degree which left us in a very vulnerable position. Table 4 indicates the main sources of our imports of principal foods and feedingstuffs during the

TABLE 4

MAIN SOURCES OF IMPORTS OF PRINCIPAL GROUPS OF FOOD AND FEEDINGSTUFFS, ANNUAL AVERAGE, 1934-38

From *How Britain was fed in War Time*, H M S O, London, 1946

Commodity Group	Imports '000 tons	Main Sources, i.e. those supplying 10 per cent or more of group total
Wheat and flour	5,451	Canada, 39 per cent, Australia, 24 per cent, Argentina, 15 per cent
Rice, other grains and pulses (including soya beans and products)	1,527	Canada, 18 per cent; British India, Burma and Kwantung, 13 per cent, Iran and Iraq, 11 per cent; Soviet Union, 11 per cent
Animal feedingstuffs (including maize and maize meal)	5,114	Argentina, 57 per cent, British India and Burma, 11 per cent
Meat (including canned meat and bacon and ham)	1,486	Argentina, 32 per cent, Australia and New Zealand, 32 per cent, Denmark, 13 per cent
Oilseeds and nuts, oils and fats	1,783	Egypt and Sudan, 24 per cent, British India, Burma and Ceylon, 20 per cent; British West Africa, 18 per cent
Sugar	2,168	Cuba and S Domingo, 37 per cent, Australia, 15 per cent, Mauritius, 11 per cent
Dairy produce	889	Continental Europe (inc Soviet Union), 45 per cent, Australia and New Zealand, 39 per cent
Fruit and vegetables (including tinned and preserved)	2,604	Europe (including Channel Islands and Soviet Union) and Canary Islands, 37 per cent; U S A., 12 per cent.

CHAPTER IV

THE PROBLEM OF NUTRITION IN GREAT BRITAIN (*contd.*)

THE FOOD SITUATION DURING THE WAR, 1939-45

THAT the experiment in food control during the first Great Wa bore not a little fruit is shown by the activity of the Board o Trade in setting up in 1937 a Food Department, the precis function of which was to investigate the most effective mean for the supply and distribution of cereals, meat, butter, bacoi and sugar in the event of a major conflict in Europe. Initia activity, however, was not the earnest of a continuing purpos

TABLE 3

PRE-WAR FOOD CONSUMPTION IN THE UNITED KINGDOM SHOWING THE PERCENTAGES HOME-PRODUCED AND IMPORTEI

From *How Britain was fed in War Time*, H M S O , London, 1946

Commodity Group	Annual Average 1934–38		
	Total '000 Tons	Percentage Home-Produced (a)	Percentage Imported
Flour from wheat and other cereal products	4,428	12	88
Fats (butter, lard, margarine)	905	7	93
Sugar	2,184	18	82
Meat (including bacon)	2,707	45	55
Fish (including canned) (edible weight)	523	85	15
Eggs and egg products	500	60	40
Milk (liquid)	4,579	100	—
Condensed milk	260	70	30
Dried milk	35	61	39
Cheese	185	24	76
Potatoes	3,700	94	6
Other vegetables	2,715	92	8
Fruit (including tomatoes)	2,406	26	74

(a) Partly dependent on imported feedingstuffs

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TABLE 8

PRE-WAR FOOD CONSUMPTION IN THE UNITED KINGDOM SHOWING THE PERCENTAGES HOME-PRODUCED AND IMPORTED

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Fruit (including tomatoes) .	2,406	26	74

(*a*) Partly dependent on imported feedingstuffs

foods in accordance with the standard of living and determines the ration of any food per head per week in accordance with the physiological requirements of the people. And the people are composed of mothers, infants, children, adolescents, men and women employed in various activities, invalids and old people. All these groups have different needs in terms of energy and of body-building foods; they must therefore be catered for on the basis of a scientific knowledge of their physiological needs. Present-day knowledge of these physiological needs was quite sufficient to guide the Ministry of Food in developing their system of rationing whereby food control was exercised

THE RATIONING SYSTEM

The scheme of rationing was based upon the issue of coupons whereby the retailer supplied, and the customer obtained, rationed foods against the appropriate coupons

Butter, Bacon and Sugar.—Rationing was operated on either a per head weekly or a four-weekly basis. This was begun on the 8th of January 1940, with butter, bacon and sugar. While the ration of bacon ranged from 4 to 8 oz per head per week, it was mostly held at 4 oz. Butter and margarine (the latter included on 22nd July 1940), with short-lived exceptions, were rationed in the amounts of 2 and 4 oz. respectively, with cooking fats at 2 oz. For the Christmas week 1944 the margarine ration was raised to 12 oz.

Sugar.—Sugar rationing commenced with 12 oz. per head per week and continued after May 1940 at 8 oz. per head per week. On certain occasions, as for the weeks preceding Christmas, a special additional ration of 4 oz. in 1940 and 1941 and 8 oz. in 1944 were made, and on other occasions the sugar ration was exchangeable for preserves, in 1943 the rate being 1 lb. of sugar for 1 lb. of preserves and in 1944, 1 lb of sugar for 2 lb of preserves.

Throughout the war the basic ration of sugar was, with one short exception in 1941, constant at 8 oz. per head per week. The total sugar content of sugar, jam, marmalade, honey and glucose moving into civilian consumption fell from a pre-war figure of 33 8 oz. to 21·98 per head per week in 1943; this represented a fall of 35 per cent. At appropriate seasons extra sugar was made available for preserving fruit and in lieu

pre-war period 1934–38. The invasion of Denmark and Norway in April 1940 and of the Low Countries in May, and the final capitulation of France on 25th June were responsible for the immediate loss of sources of supplies amounting to almost 2 million tons annually The most important imports lost were bacon and ham 55 per cent, condensed milk and milk powder 77 per cent, shell eggs 52 per cent and butter 30 per cent. This and the extension of the war to the Near, Middle and Far East altered the whole trend of our importation of foodstuffs.

Immediately upon the declaration of war in September 1939, there was established, under Lord Woolton, a Ministry of Food which was to prove one of the most successful of all War Ministries. Realizing the importance of the morale of the civilian population in fighting a total war, the Ministry, through various Scientific Advisory Committees, decided upon a food policy flexible enough to meet the ever changing vicissitudes of war, but having one all important aim, the adequate distribution, to all classes of the community in accordance with their physiological requirements, of those foodstuffs deemed essential to the maintenance of bodily health and vigour. With rapidly growing armies and a tremendous increase in industrial activity, the like of which this country had never seen, the problem became essentially one of limited importation and maximal home production of food. The Ministry assumed full control over the purchase and distribution of essential foods for human consumption and feedingstuffs for live stock. The effective handling of this vast problem was made possible by the integration of the work of numerous Advisory Committees representing shipping, industry, agriculture and medical science. Local Food Committees and Food Advice Centres were formed; British Restaurants and Canteens were established in industrial areas; and, by means of numerous publications, statements in the daily Press and announcements on the air by the British Broadcasting Corporation, much valuable information on what to grow, what to eat and how to cook it was imparted to the general public.

The crux of the problem of maintaining the physical and mental fitness of a nation is food distribution. Without an adequate diet available to all, no nation can be expected to survive the crisis of a great war or hope to become socially progressive or politically stable Effective distribution demands control from the centre, a control which fixes the price of essential

in 1942, and the zoning of deliveries in towns with a population of 10,000 or over.

In view of the increased demand for milk and despite increased production and limited supplies of fresh milk, National Household Milk powder was made available during the winters of 1942–43, 1943–44 and 1944–45. National Household Milk was made from spray dried skimmed milk; the distribution was based on sugar registration and the allowance was one tin to each customer in two four-week periods: one tin contained the equivalent of four pints of milk.

Eggs.—Under the Egg Control Scheme, put into operation in June 1941, consumers had to register with a retailer for shell eggs, allocations of which were made from time to time. Priority classes for shell eggs, first introduced on 17th November 1941, were nursing and expectant mothers, infants from 6 to 18 months and invalids: they received 4 eggs per week. A year later the number of eggs was reduced for priority classes to 3 per week, children under 5 years of age to 1 per allocation.

The shortage of egg supply led to a controlled distribution of dried eggs from 24th June 1942. On 7th March 1943 priority was granted for infants between 6 and 18 months but not for infants under 6 months of age, at the rate of 3 per week. One packet of dried eggs, equal to 12 eggs, was given per allocation to each customer registered for shell eggs.

Oranges.—In the interests of children of 6 months to 2 years and of expectant mothers, cod-liver oil and orange juice were made available through various food centres from the beginning of 1942, and priority distribution of oranges was undertaken to limited areas as supplies were received. With the close of the German war, supplies increased and by September 1945 the supply by allocation of oranges to the public became more frequent.

As preserves, jam, marmalade, syrup and treacle were rationed from 17th March 1941; on 26th July 1942 syrup and treacle were transferred to the points scheme of rationing. As required, either additional sugar for the making of jam was released or the preserve ration became interchangeable for sugar at the rate of 1 lb. of preserves for 1 lb. or 8 oz. of sugar.

To determine the efficiency of this method of control of essential foods, the consumption and expenditure per head per week of all the foodstuffs which made up the average war-time

of preserves, the latter being generally of the nature of ½ lb. sugar for each lb. of preserves.

Meat.—During 1940 meat was rationed at an average of 1s. 10d. per head per week; in 1941 it was valued, on an average for the year, at 1s. 2d. per week, and remained so until 1945.

Cheese.—The cheese ration suffered considerable variation; in 1941 it varied from 1 to 3 oz. per head per week; in 1942 it was 4 oz. for the first half and 8 oz. for the second half of the year; for the greater part of 1943 it was 3 oz. and in 1944 it was 3 oz. in the winter and 2 oz. in the summer and early autumn. A special ration of cheese was made available for certain classes of workers, to whom canteens and British Restaurants were not available, such as agricultural workers, miners, fishermen, forestry workers, etc. Vegetarians were given extra cheese rations in lieu of meat and bacon. From 5th May 1941 their ration was 8 oz. per week per head; in December 1941, 12 oz.; on the 26th July 1942 it was again raised to 16 oz. and returned to 12 oz. on 10th January 1943.

In December 1941 a system of points rationing was introduced whereby the consumer could purchase within a period of four weeks certain foods wherever obtainable. These "points" covered at first canned meats, beans and fish, but later they were made to cover a wide range of foods. The distribution of chocolate and sugar confectionery was controlled by a system of "personal points" rationing.

An interesting feature in the distribution of essential foods by the Ministry of Food was the control, through priority groups, of milk, milk powder, shell eggs, dried eggs and oranges.

Milk.—Under a National Milk Scheme, beginning 21st July 1940, expectant mothers and all children under 5 years of age were entitled to 7 pints per week. Children and adolescents, from 5 to 18 years of age, received 3½ pints per week, and all children between 5 and 14 years who could not attend school, were allowed 5 pints per week as from 6th October 1942 Invalids could, on a doctor's certificate, receive up to 2 pints per day. The Milk in Schools Scheme whereby on school days all scholars, if they so wished, could receive one-third of a pint of milk at the cost of ½d., was already in force. To non-priority groups no definite quantity of milk was guaranteed. Important in the plans of the Ministry of Food for the economical distribution of milk was the nationalization of milk distribution

Calories as consumed (2370) with that representing Calories passing into civilian consumption (2870) (Tables 6 and 7 (1942)). On practical grounds it may be broadly stated that, viewing the experiment in national feeding as a whole, a food equivalent of 3000 Calories per head per day should pass into consumption and that, allowing a margin to cover losses in the distribution and cooking of food, 2600 Calories per head per day should represent the amount of food eaten.

If all children had been enabled to obtain midday meals in school, and had women with children been afforded the facilities of more extensive war-time nurseries and, using these, had fed daily at a British Restaurant or a work's canteen, then with the exception of the lower income groups, the adequacy of the war-time dietaries would have much more closely approached minimum requirements. Certainly the nutritional condition of a beleagured nation required constant vigilance on the part of the Ministry of Health, and the approach to minimum nutritional requirement could only be viewed with a sense of satisfaction in view of the perilous state in which we were living. But it must be admitted that no diet, which is characterized by monotony, difficult planning, uncertain shopping and is not enlivened by a freedom of choice, can be regarded as wholly adequate, no matter how perfectly it may meet the required standards for calories and nutrients.

DETAILS OF FOOD CONTROL AND COMPARISON OF RESULTS

In carrying out dietary surveys month by month from 1942 onwards, the Ministry of Food placed essential foodstuffs in twelve categories. See Table 5. These were :

Dairy Products—milk (fresh liquid, national school, skimmed, condensed whole sweetened and unsweetened, condensed sweetened skimmed, dried whole and dried skimmed) and cheese.

Meat—beef, mutton and lamb, pork, offals, canned meat, bacon and ham.

Fish, Poultry and Game—fresh, frozen, fried and canned fish, rabbit.

Eggs—shell, dried and liquid.

Oils and Fats—butter, margarine, lard, edible oils and fats.

diet were noted by dietary and budgetary surveys carried out by several bodies, such as the Ministry of Food, the Ministry of Health, the Combined Food Board of the U.S.A., Canada and the United Kingdom, the Department of Health for Scotland and the Oxford Dietary Survey.

In the United Kingdom, the value of rationing was soon apparent. *By the winter of 1940 there was a marked fall in* the consumption of meat, poultry and fish, sugar, fats and fruit. This meant a loss of valuable nutrients particularly of animal protein and fats. The fall in sugar was largely offset by a rise in the consumption of bread and potatoes. The period of greatest food shortage was in the first six months of 1941 when, due to the reduction in sugar to 8 oz. per head per week, preserves to 8 oz. per head per month, and edible fats to 8 oz. per head per week, the amount of supplies moving into civilian consumption were equivalent to, approximately, 2680 Calories, 33 grams of animal protein and 105 grams of fat per head per day. At this time dietary surveys showed that, in approximate figures, heavy workers were receiving diets which gave them 2627 Calories, 77 grams total protein, 28 grams of animal protein, 380 grams of carbohydrate, 81 grams of fat, and 720 milligrams of calcium Lower income groups were receiving about 300 Calories less, due mainly to restrictions in sugar and fat and their inability, during a time of great stress and strain, to make full use of rationed and unrationed foods. Improvement was apparent late in 1941, when lease-lend supplies arrived from the U.S A. and was maintained by increased home production of vegetables, potatoes and fresh fruit, as also by the increase in the extraction of flour to 85 per cent. A steady increase in the amount of milk and milk products consumed also added to this improvement by increasing animal protein and calcium. In 1942, surveys showed heavy workers receiving 2647 Calories, 86 grams total and 35 grams animal protein, 349 grams of carbohydrate, 93 grams of fat and 820 milligrams of calcium, while the Ministry of Food surveys showed urban working class households to be receiving 2339 Calories and 2269 Calories in 1941 and 1942 respectively. The chief deficiencies were still in Calories, animal protein, fat and calcium.

Interesting as a comment on national economy in the handling of food is the comparison of the average figure representing

within the group. The advantage of this is shown in Tables 5 and 6 For example, during the war dried eggs generally replaced shell eggs, canned meat replaced carcase meat and dried milk replaced fresh milk. The pre-war figures given as a basis of comparison are the averages for the years 1934 to 1938 and the factors for the conversion of food supplies into terms of nutrients are derived from tables compiled by the Medical Research Council and the Food and Agriculture Organisation. No allowance has been made for wastage in retail shops or the home but in calculating nutrient intakes (Table 6) allowance is made for inevitable losses in the preparation of food for the table.

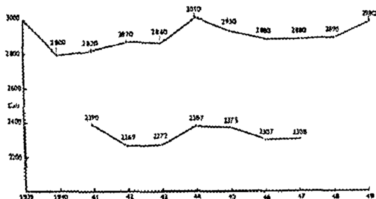


Fig. 5 —Chart indicating the gap between Calories per head per day determined by (a) estimating food passing into civilian consumption (upper curve), (b) dietary surveys of communities (lower curve)

A graphic representation of war and post-war changes as detailed in Tables 5 and 11 is given in Figs 6-12 which are at the end of this chapter.

Milk.—The policy of the Government was to encourage the production of fresh liquid milk. The amount of milk moving into consumption increased by 1944 to 41 per cent above the pre-war amount *Despite the increase in consumption* from 3 30 to 4 66 pints per head per week there was in 1942 a marked diminution in the supply to non-priority groups. That the priority groups received their supplies at the expense of non-priority groups was sound national policy. Non-priority consumers made up their deficiencies by the use of condensed milk and dried skimmed milk (National Household Milk).

Sugar and Syrups—sugar, jam, marmalade, honey and glucose.

Potatoes.

Pulses and Nuts—peas, beans, soya flour and edible nuts.

Fruit—fresh, canned and dried, including tomatoes.

Vegetables.

Grain Products—flour, barley, oats, rye, cereals, rice and starch, tapioca and sago.

Beverages—tea, coffee, cocoa.

About one hundred specific foods were checked. The trends in food consumption during the war can be sufficiently well indicated if the more important of these categories be examined (see Table 5).

The method used by the Ministry of Food in calculating the national average level of food consumption by the civilian population is that devised by a Special Joint Committee set up by the Combined Food Board in 1943. This method was used in revising the figures from 1934–38 to 1943. It should be noted that the total food supplied to the nation does not equal the amount of food consumed by the civilian population and therefore in order to arrive at figures which represent the supplies of all food *moving into civilian consumption*, deductions must be made from the total food supplied to the nation, be it imported or home produced, of foods set aside for industrial and other non-food purposes, export and supply to the Armed Forces, seed and feeding to live stock. The figures so obtained, generally termed *food consumption levels*, relate to the population as a whole and indicate the amount of food which reaches the retail shops, schools and catering establishments. And further it should be noted that these latter figures are higher than those obtained by dietary surveys which give data for selected groups of the population. Much unnecessary confusion and controversy would be avoided if the differences between these two methods were clearly borne in mind when discussing the nutritional status of the nation. Fig. 5, showing only the difference in Calories between the two estimates, will give warning that similar differences may exist in a survey of all nutrients.

The Ministry of Food have pointed out that it is frequently more significant to consider food groups instead of individual foods, because of the substitution of one food for another

1943 saw the basic ration fall from 6 to 3 oz., the special ration remaining stationary. During the summer months of 1944 the basic ration was reduced to 2 oz. and, after being raised to 3 oz on the 15th October 1944, it was again reduced to 2 oz. on 1st April 1945. Pre-war consumption of cheese was 2 71 oz. per head per week. During 1941 the amount moving into civilian consumption was 2 55 oz. and in 1942 it was 4 3 oz. per head per week; during the ensuing three years it fell steadily towards the pre-war level.

Meat.—In the pre-war period 1934 to 1938, the total amount of meat passing into civilian consumption in this country was 112·4 lb. per head per year; for the U.S.A. and Canada it was 111·7 lb. and 97·3 lb. per head per year respectively. In terms of first quality beef, that is beef with bone, the amount passing into civilian consumption was for the pre-war period 16·27 oz. per head per week. In 1940 the amount was 14·06 oz. and in 1941 it had fallen to 11·14 oz. per head per week; this latter figure was 68 per cent of the pre-war consumption. The year 1942 saw a further fall which reached its maximum in 1943 when the figure fell to 7 21 oz. per head per week In 1944 it rose to 8 38 oz., approximately half the pre-war consumption. The quality of the meat supplies suffered some deterioration due to the stoppage of the importation of high quality chilled beef, the reduction in home production to conserve bread grain for human use and the great increase in the import of frozen boneless meat. The amount of frozen meat coming into civilian consumption rose rapidly from 0·52 oz. per head per week pre-war to 2·15 oz. in 1941 and to 4·78 oz. in 1942; this was equal to an increase of 800 per cent. The following year there was a fall in the consumption of frozen meat to 2·88 oz. per head per week, at which figure it remained throughout 1944.

The marked fall in the consumption of first quality beef, coupled with a fall in 1940 of the supplies of bacon and ham, was largely offset by an increase in the use of canned beef and frozen boneless meat. It was largely due to the tremendous effort of Canadian producers that the consumption of bacon and ham did not fall below 25 per cent of the pre-war figure in 1940 and did not at any time fall below 30 per cent of the pre-war figure. (Fig. 7.)

To secure as equitable a distribution of meat as possible, butcher meat was rationed from 11th March 1940 at 1s. 10d.

The production of cream and ice cream was prohibited from 1941 until 1944. The steady upward trend in milk consumption is more marked if one compares the consumption for the third quarter for the years 1941 and 1942; it was 2·7 and 3·2 pints per head per week respectively. In the winter quarters there was the usual seasonal fall in consumption. In 1942 a 30 per cent increase in the amount of milk supplied to priority groups was due to an increasing consumption of milk in schools and in households where priority milk was due. It is also noteworthy that at this time expenditure on milk supplies increased and less free milk was accepted, a situation arising from the increased amount of free money available in this country. In this connection it is interesting to compare the milk consumption in industrial and non-industrial towns as shown by surveys during the month of November 1935 and 1944; towns such as Jarrow, Wallsend and Seaham, which had suffered greatly in the pre-war industrial depression, showed a rise from 0·14 pints to 0·52 pints per head per day, while non-industrial towns showed no marked change from a general average of 0·50 pints per head per day. On 15th July 1945, milk for non-priority groups was reduced from 3 to 2½ pints per head per week. Before the war, condensed milk was used largely by working classes, dried milk almost not at all. When powdered milk was introduced, the highest economic groups were much bolder in experimenting with it than were the lower economic groups. This may have been due to the fact that in those higher economic groups greater use was made of fresh milk and, therefore, when milk became scarce, and housewives, feeling that milk should not be omitted from the dietary, did their best to supplement their diminished supplies of fresh liquid milk by means of dried milk. It has been stated that if the powdered milk had been of the highest grade of production and had not therefore lost too much of its fat content, the general public, if capable of making it up properly, would have been unable to differentiate with any degree of accuracy between reconstituted milk and fresh milk. (Fig. 6.)

Cheese.—On 5th May 1941 the ordinary cheese ration was only 1 oz. per head per week, on 30th June, 2 oz. and on 25th August 1941 it was raised to 3 oz. On 1st June 1942 the basic ration was 4 oz., the special ration 8 oz., and they were raised to 8 oz. and 12 oz. respectively on 26th July 1942. The year

egg powder, equivalent to 12 eggs, per allocation for every customer registered for shell eggs. During 1941–42, there was a very definite and continued fall in the production of shell eggs, and concomitantly, dried egg powder reached its highest point of consumption in the winter of 1943–44 Despite much propaganda, it was not a popular substitute for the shell egg, as was shown by the rapid increase in the purchase of shell eggs as soon as this became possible in the summer of 1945. Of course, this increased use of shell eggs was seasonal and during the winter months the public had perforce to make a greater use of dried egg powder. [illegible] e was a marked improvement i [illegible] nprovement the more striking [illegible] as it obtained in 1943–44, when the supply of shell eggs had fallen by 55 per cent of the pre-war figure. This tremendous fall in shell egg consumption was almost made good by the use of dried eggs *which are nutritionally, but not entirely in the culinary sense,* equivalent to shell eggs. On 22nd July 1945, the allocation of 8 shell eggs per week for children of 6 to 18 months was extended to children up to 2 years of age. (Fig. 9.)

Dehydrated foods, by loss of water, suffer alteration of protein structure which will to some extent prevent on reconstitution the development of the full flavour, appearance and taste of the food. It is extremely difficult to get people to like a new type of food unless one is prepared to see to it that the new type of food can be well reconstituted, that a considerable period of time is taken over its introduction and that the public is fully instructed in the best methods for its use. That the Ministry of Food was fully alive to these points was demonstrated by their propaganda and the setting up of Food Advice Centres.

Butter and Margarine.—Before the war butter consumption in this country was 7·61 oz. per head per week. At the end of 1940, the consumption rate had fallen by 44 per cent and in 1944, by 70 per cent of the pre-war figure. This fall was entirely offset by an increase of almost 100 per cent in the consumption of vitaminized margarine. (Fig. 10.)

Bread.—Extraction and dilution of wheat flour were the subjects for discussion in the first world war, extraction and fortification the bases of discussion in the second. In July 1940, the Accessory Food Factors Committee of the Lister

worth per head per week. In September 1940 the price was raised to 2s. 2d. but fell to 1s. 10d. in December 1940 and to 1s. 2d. on 9th January 1941. From 31st March to 6th July 1941, the value was 1s. per head per week, but it was again raised to 1s. 2d. on 7th July 1941, and that level was virtually maintained up to 1945. Children from 18 months to 5 years —that is, holders of Child's Ration Book RB2—had half a ration of meat, children 5 years and over were entitled to an adult ration of meat.

Numerous varieties of canned meats were on points rationing. Offals, meat pies and sausages, because of their perishability, were not rationed. The meat content of sausages was fixed at 37·5 per cent; some latitude in fulfilling this prescription was allowed. The nutritive value of sausages was improved when the addition of 7·5 per cent of low fat soya grits became compulsory on 25th July 1943.

Fish.—Fish, particularly cheap fresh fish, suffered a marked reduction in supply, due to the acquisition by the Admiralty of many trawlers for naval work. The consumption of fresh fish fell in 1940 to 51 per cent of the pre-war intake which was 6·7 oz. per head per week; in 1942 it was 63 per cent, in 1943 it was 65 per cent and in 1944 it was 73 per cent of the pre-war value. This latter figure represents an intake of 4·9 oz. per head per week. The consumption of canned fish remained almost at the pre-war figure throughout, with the single exception of the year 1940 when it was 44 per cent above the 1938 level. (Fig. 8)

Eggs.—The lack of shell eggs was one of the major deprivations of the war. In 1935 the average number of eggs eaten was 3 per head per week of the population; in 1937–38 the number was 3·4; in 1941 it had fallen to 2·3 and in the winter months of 1942 it was one-fifth of an egg per head per week. Such a situation was not unforeseen, for the control of shell eggs came into force on 30th June 1941, and five months later priority supplies were announced for nursing mothers, children under 5 years and invalids. In 1941 priority groups received 4 shell eggs per week, in October 1942 nursing mothers were allowed 3 eggs per week, children 1 egg per allocation. In March 1943 a priority at the rate of 3 eggs per week was given for infants between 6 and 18 months old. Such priorities were physiologically well founded, and the deprivation of other groups occasioned thereby was offset by the allowance of 1 packet of dried

in the production of 82½ per cent extraction flour, could produce an 80 per cent extraction flour, the nutrient percentage of which equalled that of the 82½ per cent flour.

Fruits.—Supplies of fresh citrus fruits fell very rapidly in 1941, until, in 1943, 92 per cent of all fresh citrus fruits had disappeared from British homes. Oranges, whenever available, were subjected to a strictly controlled distribution, expectant mothers and children under 5 years of age having priority, the sale being limited to these groups for the first five days following the appearance of the oranges on the open market. The consumption of citrus juices had, by 1943, been doubled, largely by the issue of them to infants and expectant mothers. (Fig. 11.) Fresh tomatoes were maintained in good supply throughout.

Sugar.—The consumption of sugar fell from the pre-war figure of 31·9 oz. per head per week to 22 oz per head per week in 1940 and remained at about 20 oz. per head per week throughout the war period. The fall in sugar intake had apparently no bad effect upon the health of the people, due possibly to the fact that the consumption of other carbohydrate foods, particularly potatoes, increased steadily until in 1944 the carbohydrate consumption was just above the pre-war figure.

Potatoes.—More potatoes and vegetables were possibly eaten than the figures show, since these were grown by many

84·40 oz. per head per week, a 56 per cent increase upon the pre-war level of 54 oz. per head per week (Fig. 12)

In this brief account of the feeding of a nation in war-time no reference has been made to the difficult task of maintaining a steady flow of foodstuffs to the Navy, Army and Air Force in all parts of the world, but it will be readily realized that the feeding of the people of the United Kingdom was but one aspect of the whole gigantic problem facing the Government.

In Table 5 is given a summary of the changes in the consumption of the principal foods; the rates of consumption from 1938 to 1944 are given and the changes from 1938 to 1944 stated as a percentage of the 1938 figures. A detailed comparative statement of the consumption of foods in the U.S.A., Canada and the United Kingdom throughout the period of the

Institute and the Medical Research Council recommended that extraction should be 85 per cent, on the knowledge that flour of high extraction contained appreciably greater quantities of iron and vitamins of the B group than white flour. Acting on this advice, the Ministry of Food placed on the market the National Wheatmeal Loaf. This was in the spring of 1941, and during this year the national wheatmeal loaf was certainly not popular. This may have been due to its lack of palatability, poor keeping properties, uncertain colour, all of which may have been the result of allowing the bakers to make up an 85 per cent extraction by adding bran to white flour. In March 1942, as a result of shipping losses, the milling of 85 per cent extraction flour was made compulsory, and in June 1942, the Medical Research Council advised that the bran content of the flour should be brought down from 6 to 4 per cent, an alteration which led to an improvement in colour and quality. In the same year flour was fortified by the addition of 7 oz of calcium carbonate to the 280 lb. sack of flour; this was done to counteract the calcium binding power of the increased proportion of phytic acid in the 85 per cent extraction flour, and incidently improved the calcium intake of the population. Previous to April 1942, about 96 per cent of the people were eating white bread. Sir W. Crawford and H. Broadly in *The People's Food* (1938), state that, in the highest economic groups the ratio of white to brown bread eaten was 8·7 to 1, while in the lowest groups it was 28·7 to 1. It was also noted that the highest economic groups reacted more favourably than the lowest to the national loaf, but after about one year, it was still apparent that 50 per cent of the people continued to favour white bread and only about 25 per cent were wholly in favour of the new loaf. Several reasons were forthcoming for this unfavourable attitude; on the question of taste 50 per cent of consumers still continued to favour white bread, about 30 per cent accepted it, the remainder were doubtful or uninterested. As to its nutritive value, again about half of the people realized that the national wheatmeal loaf was better than white bread. Not a few complaints referred to the lack of those cutting and keeping properties which characterize white bread. The national loaf was an experiment, the results of which were fully realized by 1945, but are now apparently being rapidly forgotten. Millers, after 3 or 4 months' experience

TABLE 5 (*contd.*)

	oz per head per week (except milk and eggs)					
	Pre-war Average 1934–38	1940	1941	1942	1943	1944
Eggs						
(*a*) Shell eggs, No	3 1	2 7	2 3	1 7	1 4	1 4
As percentage of pre-war (*a*)	—	87	74	55	45	45
(*b*) Shell egg equivalent of shell, dried and liquid eggs, No	3 43	3 20	2 74	3 00	3 15	3 31
As percentage of pre-war (*b*)	—	93	80	88	92	97
Oils and Fats						
Butter .	7 61	4 30	3 10	2 36	2 33	2 36
Margarine	2 67	4 73	5 38	5 34	5 22	5 46
Lard .	2 82	2 79	3 07	3 65	3 62	3 72
Edible oils and fats .	2 52	2 30	2 06	2 03	1 69	1 69
Total (fat content)	13 91	12 65	12 28	12 15	11 65	11 97
As percentage of pre-war	—	91	88	87	84	86
Sugar and Syrups						
Sugar	31 9	22 00	20 60	21 30	20 80	21 92
Jam and marmalade (imported) .	0 03	—	0 09	—	0 61	0 64
Honey and glucose	2 20	2 15	1 22	1 10	0 98	1 07
Total (sugar content)	33 8	23 82	21 60	22 16	21 98	23 25
As percentage of pre-war .	—	71	65	66	65	69
Potatoes	54 15	51 20	57 80	69 20	76 22	84·40
As percentage of pre-war	—	95	107	128	141	156
Fruit						
Fresh tomatoes	3 20	2 52	2 12	2 64	2 73	2 52
Fresh citrus fruits	8 75	6 26	1 23	1 44	0 61	2 15
Other fresh fruit	15 15	11 95	3 87	9 99	8 20	7 74
Canned fruit (not citrus)	3 13	1 96	0 58	0 89	0 89	0 21
Total (fresh equivalent) . .	43 30	33 30	18 25	28 85	23 90	28 73
As percentage of pre-war . . .	—	76	42	67	55	66

Table 5

SUMMARY OF FOOD SUPPLIES PER HEAD PER WEEK MOVING INTO CIVILIAN CONSUMPTION IN THE UNITED KINGDOM, 1934–1944

Compiled from data in *Food Consumption Levels*, H M S.O., 1944, 1947, 1949, and *Statistics Relating to the War Effort in the United Kingdom*, H M S.O., 1944

This includes foods used in catering establishments and quantities used for food manufacture and also food produced by the people for their own consumption. This explains those figures which are higher than the domestic ration

	oz per head per week (except milk and eggs)					
	Pre-war Average 1934–38	1940	1941	1942	1943	1944
Dairy Products (excluding butter)						
Liquid milk (pints)	3 30	3 52	4 00	4 30	4 50	4 66
As percentage of pre-war (milk, pints)	100	107	121	130	136	141
Cheese . . .	2 71	2 51	2 55	4 30	3 53	3 12
Evaporated milk	0 74	0 37	1 10	0 92	0 52	0 49
Condensed milk	3 04	2 08	0 59	0 67	0 98	0 78
Dried whole milk	0 18	0 17	0 12	0 18	0 25	0 31
Dried skim milk	0 31	0 33	0 12	0 71	1 04	0 67
As percentage of pre-war (milk solids) .	—	100	106	127	131	128
Meat						
Beef—bone in	16 27	14 06	11·14	7 52	7 21	8 38
Beef—bone out .	0 52	0 68	2 15	4 78	2 88	2 85
Mutton and lamb	7 74	9 25	6 64	7 40	8 05	6 88
Pork .	3 53	3 01	2 09	1 50	2 27	4 54
Offals	2 27	2 15	1 87	1 97	1 72	2 09
Canned corned meat	0 64	—	0 12	0 74	1 01	0 03
Other canned meat	0 25	0 34	0 61	1 53	1 41	1 78
Bacon and ham	8 30	6 20	5 86	5 96	5 68	7 24
Total (edible weight)	33 65	30 40	26 30	27 50	26 60	29 50
As percentage of pre-war	—	90	78	82	79	88
Fish (fresh, frozen, cured and canned) .	8 22	5 20	4 60	5 12	5 50	6 15
As percentage of pre-war .	—	64	56	62	67	75

requirements. It is to be remembered that by a more equal distribution of foods to all classes of the community and with the intakes mentioned, the people of the United Kingdom maintained a remarkably good health record during five years of total war. It will be admitted, without question, that in peace time the full dietary requirements should be attained by all, but the standards generally referred to in the past have possibly been a little too high.

Table 6

NUTRIENT EQUIVALENT OF SUPPLIES PER HEAD PER DAY MOVING INTO CIVILIAN CONSUMPTION IN THE UNITED KINGDOM

Compiled from *Food Consumption Levels in the United Kingdom*, H M S O , 1949

		Per head per day					
		Pre war	1940	1941	1942	1943	1944
Protein—							
Animal	g	42 7	38 3	35 7	40 3	39 8	41 4
Vegetable	g	37 2	40 4	46 7	46 3	45 5	45 7
Total	g	79 9	78 7	82 4	86 6	85 3	87 1
Fat from all sources	g	130 2	120 7	113 4	118 9	115 3	124 0
Carbohydrate	g	377 0	350 1	367 5	363 8	370 0	386 3
Calcium	mg	693	677	698	838	1,032	1,039
Iron	mg	12 4	12 7	12 9	15 5	16 0	16 2
Vitamin A	I U	3,997	3,685	3,604	3,795	3,565	3,779
Ascorbic acid	mg	96	86	81	97	97	105
Vitamin B_1	mg	1 2	1 3	1 5	1 7	1 9	2 0
Riboflavin	mg	1 6	1 6	1 6	2 0	2 0	2 1
Nicotinic acid	mg	13 4	13 6	13 0	14 0	14 6	16 0
Energy values—Calories		3,000	2,800	2,820	2,870	2,860	3,010

Calories.—Dietary surveys carried out during the war showed that Calories were on an average some 10 per cent below the normal, total protein was, on the other hand, well maintained for adults in all but the lowest income groups, but not for adolescents.

Protein.—Throughout the 5 years from 1940–45 there was no essential change in the average amount of total protein ingested. Low income groups suffered up to 15 per cent deficiency; higher income groups suffered no deficiency.

TABLE 5 (*contd.*)

	oz per head per week (except milk and eggs)					
	Pre-war Average 1934–38	1940	1941	1942	1943	1944
Vegetables	33 00	30 20	33 50	36 60	35 90	38 60
As percentage of pre-war	—	92	101	111	109	116
Grain Products						
Flour	59 60	64 00	72 80	69 60	70 70	71 35
Total grains .	64 50	69 40	79 80	75 50	76 56	77 65
As percentage of pre-war . .	—	107	122	117	118	120
Beverages						
Tea, coffee, cocoa	4 52	4 78	4 48	4 30	3 60	3 93
As percentage of pre-war .	—	106	99	95	78	87

war has been published in *Food Consumption Levels*, 1944, 1947 and 1949, issued by H.M. Stationery Office.

Nutrients.—From the data in Table 5 the average number of Calories and the average amount of nutrients per head per week made available to the people have been computed and are shown in Table 6. These figures represent in general terms the amount of food passing into civilian consumption and give no clue to the extent to which the available foods were taken up by different sections of the population. This latter point can only be decided, and that only approximately, by repeated dietary surveys. Table 7, made up from dietary and budgetary survey data, shows how varied can be the intake of nutrients despite controlled distribution of essential foods, and indicates, as these surveys always do, how important in the feeding of families is the amount of the net income (i e income available after rent and taxes have been deducted from the total weekly earnings). Table 7 shows quite clearly how impossible it was to obtain an adequate diet where the income was less than 10s. per head per week.

The dietary intake of the nutrients per head per week of the population did not in all respects fulfil the physiological

have a sufficiency of calcium stored in their bones to prevent the development of any untoward deficiency, but children and nursing mothers are not in such a favourable position. These are nationally the most important categories and any criticism, and there has been some, of priority milk for these is based either on ignorance or prejudice.

Vitamins.—In the lower income groups vitamins A and B were reduced, vitamin A on some occasions being as low as 44 per cent of the required amount. The fall in vitamin A may at times have been due to a reduction in the consumption of liver. If the usual figures for vitamin C be accepted then vitamin C showed some serious deficiencies and only short seasonal increases above the normal; at the end of the winter months or in the early spring, the amount of vitamin C in the dietaries of the people was reduced for all groups and, on occasion, for the lowest income groups to 37 per cent of the requirement; but during the summer and late autumn with a greater consumption of green vegetables, there were short periods of two to three months in which the intake was well above normal. Since vitamin C is not stored in the human body, any increase in the intake over short periods can be regarded as of little value in preventing scorbutic conditions Vitamin C, always the least available of the vitamins, and particularly so at the end of a winter, showed as an average for low economic groups a 50 per cent fall in March 1942.

From a general survey of the food situation during the years 1943–44, one may conclude that a comparatively steady state of food consumption had been attained during these years. Having regard to the military disasters and reverses of 1940 and 1941, and the continued strenuous effort called for by all on the sea, in the air and on the land throughout the momentous year, 1942, one is surprised that, faced with unending difficulties of transport and distribution of food, the Ministry of Food was able to give the nation a diet so little removed from the normal in most of the required nutrients From monthly surveys of the dietaries of the working classes—industrial and manual labourers—the constancy of the intake of foods is marked. Seasonal variations naturally occurred in the consumption of vegetables, preserves and milk in schools, and changes due to oversea transport difficulties became manifest in the alteration of food rations and " points " distribution. By

Animal protein was diminished on an average to 35 grams per head per day; low income groups had less, probably as little as 25 grams per head per day. It is difficult to say to what extent the fall in total protein would have been detrimental to the health of the lower income groups had the war lasted one or two years longer.

TABLE 7

COMPOSITE TABLE OF DATA COMPILED FROM VARIOUS DIETARY AND BUDGETARY SURVEYS, SHOWING THE NUTRIENT CONTENT OF FOODS AS PURCHASED IN 3 INCOME GROUPS

WINTER 1941–42

		Average from all Sources per head per day	Income under 7s per head per day	Income up to 10s per head per day	Income up to 13s per head per day
Calories		2,200 (92)	1,750 (78)	2,370 (98)	3,020 (118)
Proteins—					
Total		71 (110)	55 (88)	77 (109)	102 (150)
Animal		35	28	35	42
Calcium		610 (67)	490 (54)	660 74)	790 (88)
Vitamin A	I U	2,600 (56)	1,900 (44)	2,900 (63)	4,000 (81)
Vitamin B_1	mg	1 02 (73)	0 81 (60)	1 11 (77)	1 44 (94)
Vitamin C	mg	35 (50)	25 (37)	39 (56)	58 (80)
SUMMER 1942					
Calories		2,300 (100)	2,880 (90)	2,350 (100)	2,930 (116)
Proteins—					
Total		75	65	70	84
Animal		33	24	30	37
Calcium		740 (82)	580 (64)	740 (82)	930 (106)
Vitamin A	I.U	3,200 (70)	2,300 (50)	3,200 (70)	4,400 (120)
Vitamin B_1	mg.	1 14	0 90	1 29	1 65
Vitamin C	mg	95	65	100	130

Percentage of the requirements of the sample in brackets

Calcium.—In all low income groups, that is where the family income was less than 7s. per head per week, there was in 1941–42 a very definite lack of calcium in the dietary. When one considers that milk is responsible for practically half of the calcium of the diet, a fall of 33 per cent in the intake is a serious matter. Consideration of the figures for calcium intake leads to the conclusion that priority supplies of milk to children and nursing mothers were fundamentally sound. Normal adults

meat and other foodstuffs, which were on the ration; but Major Lloyd George, in a statement made in the House of Commons, pointed out that there would be considerable difficulty in collecting ration coupons in various restaurants, canteens and eating places and, as a considerable proportion of the people in large cities fed at midday in restaurants, it was necessary to preserve a certain elasticity. That some meat went to those who

TABLE 9

MAIN SOURCES OF IMPORTS OF PRINCIPAL GROUPS OF FOODS AND FEEDINGSTUFFS, 1944

From *How Britain Was Fed in War Time* H M S O, London, 1946

Commodity Group	Imports '000 tons	Main Sources, i e those supplying 10 per cent or more of group total
Wheat and flour . .	3,024	Canada, 83 per cent, Argentina, 12 per cent
Rice, other grains and pulses (including soya beans and products)	144	U S A, 58 per cent
Animal feedingstuffs (including maize and maize meal)	216	Argentina 73 per cent, U S A, 10 per cent.
Meat (including canned meat and bacon and ham)	1,768	Argentina 33 per cent, U S A, 24 per cent, Canada, 21 per cent, Australia and New Zealand, 16 per cent
Oilseeds and nuts, oils and fats	1,968	Brit W Africa, 36 per cent, Brit India, Burma and Ceylon, 19 per cent, Argentina, 16 per cent, French W. and Equatorial Africa, 10 per cent
Sugar . .	1,156	Cuba and San Domingo, 77 per cent
Dairy produce .	664	U S A, 52 per cent, Australia and New Zealand, 35 per cent
Fruit and vegetables (including tinned and preserved)	646	U S A, 26 per cent, Europe (including Channel Is and Soviet Union) and Canary Is, 25 per cent, Union of S Africa, 12 per cent

did not require it, to the detriment of the physiological needs of others, may be quite true, but none would deny the value of the British Restaurants and catering establishments in supplying supplementary rations to men and women engaged in war work.

The loss of European markets, the institution of a lend-lease

means of the points system, introduced late in 1941, the purchase of non-rationed foods could be controlled as occasion arose. When a reduction in a main foodstuff became necessary, the loss of nutrients was made good by reducing the number of points required to purchase a foodstuff which was a good source of the principal nutrients diminished by the ration cut.

TABLE 8

FOOD CONSUMPTION IN THE UNITED KINGDOM IN 1944 SHOWING THE PERCENTAGE HOME-PRODUCED AND IMPORTED

From *How Britain Was Fed in War Time* H M S O, London, 1946

Commodity Group	Annual Average, 1944		
	Total '000 tons	Percentage Home produced (a)	Percentage Imported
Flour from wheat and other cereal products	5,492	44	56
Fats (butter, lard and margarine)	819	2	98
Sugar	1,641	27	73
Meat (including bacon)	2,577	35	65
Fish (including canned) (edible weight)	436	55	45
Eggs and egg products	279	63	37
Milk (liquid)	6,121	100	—
Condensed milk	195	53	47
Dried milk	70	21	79
Cheese	230	7	93
Potatoes	6,450	100	—
Other vegetables	3,220	99	1
Fruit (including tomatoes)	1,324	61	39

(a) Partly dependent on imported feedingstuffs

The points system helped towards a better distribution of unrationed food for it controlled supplies by preventing any run upon an essential food, the equal distribution of which was a national necessity. *That there was no increase in price in the* foodstuffs on points made it possible for all economic groups to secure their fair share. Thus the highly paid workers were prevented from buying from more than one shop and thereby securing more than their share of essential foods.

Some criticism was levelled at restaurants in that those who could afford it could, without coupons, buy extra amounts of

meat and other foodstuffs, which were on the ration; but Major Lloyd George, in a statement made in the House of Commons, pointed out that there would be considerable difficulty in collecting ration coupons in various restaurants, canteens and eating places and, as a considerable proportion of the people in large cities fed at midday in restaurants, it was necessary to preserve a certain elasticity. That some meat went to those who

TABLE 9

MAIN SOURCES OF IMPORTS OF PRINCIPAL GROUPS OF FOODS AND FEEDINGSTUFFS, 1944

From *How Britain Was Fed in War Time* H M S O, London, 1946

Commodity Group	Imports 000 tons	Main Sources, i e those supplying 10 per cent or more of group total
Wheat and flour . . .	3,624	Canada, 83 per cent, Argentina, 12 per cent
Rice, other grains and pulses (including soya beans and products) . .	144	U S A, 58 per cent
Animal feedingstuffs (including maize and maize meal)	216	Argentina, 73 per cent, U S A, 10 per cent
Meat (including canned meat and bacon and ham) . .	1,768	Argentina 33 per cent, U S A, 24 per cent, Canada, 21 per cent, Australia and New Zealand, 16 per cent
Oilseeds and nuts, oils and fats	1,968	Brit. W Africa, 36 per cent, Brit India, Burma and Ceylon, 19 per cent; Argentina, 16 per cent, French W and Equatorial Africa, 10 per cent
Sugar	1,150	Cuba and San Domingo, 77 per cent
Dairy produce . .	664	U S A, 52 per cent; Australia and New Zealand, 35 per cent
Fruit and vegetables (including tinned and preserved) .	646	U S A, 26 per cent, Europe (including Channel Is and Soviet Union) and Canary Is., 25 per cent; Union of S Africa, 12 per cent

did not require it, to the detriment of the physiological needs of others, may be quite true, but none would deny the value of the British Restaurants and catering establishments in supplying supplementary rations to men and women engaged in war work.

The loss of European markets, the institution of a lend-lease

policy with the United States, and the food requirements of armies in the Pacific helped to determine a distinct change in the proportions of imported and home produced foods, as well as the sources from which foods and feedingstuffs were obtained. The situation as it appeared in 1944 is shown in Tables 8 and 9; the former, indicating the total food consumption by commodity groups and the percentage of home produced and imported foods, the latter, the main sources of importation of the principal groups of foods. A detailed comparison of the figures relating to the items in these Tables with those in Tables 3 and 4 will reveal the changes which war produced on the home production and importation of food in the United Kingdom.

The nutritional improvement which was evident in 1944 could be laid down to the increased extraction rate of flour, an 85 per cent extraction enhancing markedly the nutritive properties of bread; to an increased intake of milk, so markedly increased that supplies were at times strictly limited and the adult ration of milk seriously reduced; and to the additional nourishment made available in the form of milk, vitamins and eggs, to the vulnerable groups of the population. That any improvement in the general health of the people could have taken place when eggs, bacon, fish, sugar, preserves and fruit were all greatly reduced is as surprising as it was satisfactory. The surprise perhaps is not so great when one realizes that the solution of the problem of the feeding of a nation depends upon an efficient distribution of essential foods and a minimum wage consonant with a required standard of living. In spite of difficulties, mistakes and disappointments, credit is certainly due to all who helped to make this experiment in national feeding the success it proved to be.

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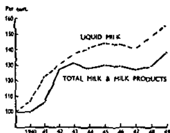


Fig. 6.

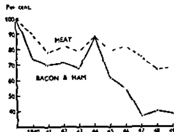


Fig 7

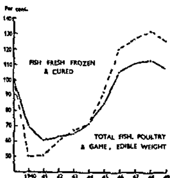


Fig. 8.

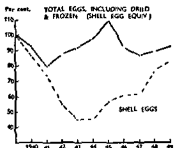


Fig 9

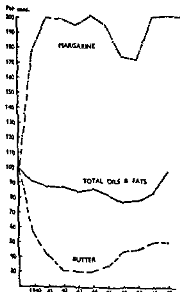


Fig. 10.

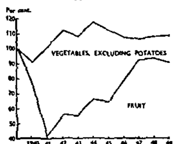


Fig 11.

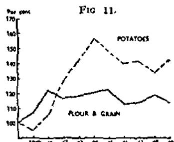


Fig. 12.

Figs. 6-12.—Civilian consumption of certain foods per head per year, 1939 to 1949, as a percentage of pre-war (1939) rate.
Drawn from data in Tables 5 and 11.

CHAPTER V

THE PROBLEM OF NUTRITION IN GREAT BRITAIN (*contd.*)

THE FOOD SITUATION DURING THE POST-WAR PERIOD, 1945-50

On 8th May 1945 hostilities ceased; in July of that year, by a surprisingly large majority, the people of this country had for the first time placed a Labour Party in a position of unquestioned power. It may safely be affirmed that no immediate post-war government has ever had to face so many crucial problems. To demobilize armies, to re-adjust our economic position, to recapture old and secure new markets, to build up an export trade in order to stabilize our financial position, and above all, to maintain the food supplies in the midst of an impoverished and starving world were some of the tasks facing the government; that they would require long vision, sound judgment and skilful handling none could deny. That these problems might have been bette [illegible]
was suggested by some; [illegible]
of statesmanship and [illegible]
needs of the devastated countries, the requirements created by political reorganization within our Commonwealth and new alignments in foreign markets created new difficulties in the feeding of the people of this country. The system of food control during the war had not only demonstrated the practical advantages accruing from an equitable distribution of food, but had given much valuable information concerning the changes in the nation's food supplies and the importance of a discriminating price control.

The following detailed consideration of the food position of the United Kingdom during the post-war period, 1945–50, is based on the data presented in Tables 5 and 11 and in Figs. 6-12 to which reference should be made as occasion requires.

Milk Rationing.—The National Milk Scheme introduced in 1940, whereby expectant mothers and children up to 5 years of age received 1 pint of milk, and the Milk in Schools Scheme

which gave school children one third of a pint at school resulted in a better distribution of milk throughout all sections of the population and an increased consumption of milk. While before the war, under welfare schemes, about 2 million gallons of milk were consumed monthly, in 1946, 19 million gallons and in 1950, over 20 million gallons per month were so consumed. Before the war about 55 per cent of school children were taking milk; in 1945 the proportion had increased to 72 per cent and

TABLE 10

MILK CONSUMPTION

MONTHLY AVERAGES (MILLION GALLONS) FOR CALENDAR MONTHS

Data from *Monthly Digest of Statistics*, Central Statistical Office, London, March, 1951

	Total (a)	Fresh Milk, Liquid Sales					Used for Manufacture (b)
		Total	National Milk Scheme		School Milk	Full Price	
			Free	Reduced Price			
1939	108 3	72 0	—	—	2 1	69 9	36 3
1945	118 7	103 6	0 3	14 5	3 9	84 9	15 1
1946	124 5	108 7	0 3	15 2	4 1	89 2	15 9
1947	120 8	108 8	0 2	15 1	3 8	89 7	12 0
1948	134 8	118 1	0 2	15 5	4 2	98 2	16 7
1949	144 6	126 1	0 2	15 4	4 2	106 4	18 5
1950	157 2	129 8	0 2	15 3	4 2	110 1	27·4

(a) Excluding milk sold outside the Milk Marketing Schemes
(b) For manufacture into milk products, including cheese made on farms

in 1949, school milk having been provided free since 1946, the returns showed that 92 per cent of school children availed themselves of this scheme. All milk unused in the schools or not taken up during the holidays was returned to general public consumption. These welfare schemes are still (1951) in operation and today, in very approximate figures, it may be stated that out of an average consumption of 5 pints per head per week 4 24 pints go into the general retail trade, 0 60 to the National Scheme and 0 16 to the Milk in Schools Scheme.—Table 10.

During the war years milk production increased by 30 per cent in the United Kingdom. Liquid milk consumption, however,

increased in 1944 by 41 per cent and in 1949 by 54 per cent of the pre-war rate, an increase from 3 3 to 5·1 pints per head per week, the highest figure ever reached. Welfare schemes supported by efficient propaganda on the nutritional value of milk, increased spending power and the reduction in imported tinned milk have contributed largely to this result—Table 11.

Milk production in this country, like harvesting, is not immune from the vagaries of the weather; thus in 1947, due to a severe winter, floods in the spring and an exceptionally dry summer, milk stocks fell below the safety limit and made it necessary for the Minister of Food to take steps in October of that year to safeguard the supply of milk to the vulnerable groups—nursing and expectant mothers and children under 5 years. All foods necessary for infant feeding were sold only on production of a child's green ration book, R.B.2, which showed that the child was not over 5 years of age; priority allowances suffered a slight reduction but the non-priority domestic allowance was not affected since it had been reduced in June 1947, from 3 to 2½ pints per week, and in August, to 2 pints. The priority allowance was restored in February and the domestic allowance in March 1948. In contrast to 1947, 1948 was a favourable year for milk production; restrictions were reduced, demand increased and manufacturers were working to full capacity. During the next two years milk production continued to improve, due to an increase in the number of cows in dairy herds and improved yields per cow. The result was the unrestricted sale of milk, for liquid consumption, from March until July 1948, when the usual restrictions due to seasonal changes came into force.

On 28th May 1950 registration with retailers was suspended. Beneficiaries under the welfare food service had still to register if they wished to have free milk or milk at a reduced price. It was decided, however, that the Milk in Schools Scheme should continue.

Table 10 shows the monthly averages of milk consumed under the National Milk Scheme, school milk and retail sale. It will be noted that in 1939, 33·6 per cent of the total produced was used for the manufacture of milk products while in 1949, 12 7 per cent and in 1950, 17·4 per cent was so used. The total amount of milk consumed in Great Britain increased from 108 3 million gallons per month in 1939 to 118·7 million gallons

per month in 1945 and to 157·2 million gallons per month in 1950; this includes school milk which increased from 2·1 million gallons per month in 1939 to 3 9 million gallons in 1945 and to 4 2 million gallons in 1950, and also the full price milk which rose from 69 9 million gallons per month in 1939 to 84 9 million gallons in 1945, and 110 1 million gallons in 1950, the balance being issued under the National Milk Scheme. Previous to the war about one third of all milk produced was consumed on farms, made into butter, fed to stock or sold privately, procedures which have been cut down due to Government schemes aimed at increasing production and improving the general distribution of milk. (Fig. 6)

Eggs.—During the war the number of shell eggs passing into civilian consumption fell to 46 per cent of their pre-war quantity but during the post-war period slowly but steadily increased until in 1949 it had reached 84 per cent. During the war dried egg consumption increased steadily and reached its maximum in 1945, since when it has fallen very markedly. The total shell egg equivalent of shell, dried and liquid egg still remains at about 92 per cent of the pre-war figure.

All eggs are sold by the Ministry of Food; the packing stations to which the eggs are sent are responsible for testing the eggs for quality (candling) and grading them by weight. On 15th October 1950, new Eggs Orders came into force; among other things they defined the categories for the classification of eggs. These categories are: (1) Home-produced fresh hen eggs marked "A"; (2) Home-produced fresh hen eggs marked "B"; (3) Home-produced fresh hen eggs marked "C", home-produced fresh duck eggs marked "A", sealed eggs marked "B" and imported eggs bearing an indication of the country of origin but not marked "C" or "S"; (4) Home-produced fresh duck eggs marked "B" and imported eggs marked "C"; (5) Home-produced fresh duck eggs marked "C", home-produced and imported eggs marked "S" and cooking eggs. Eggs in category 1 must weigh not less than $2\frac{3}{16}$ oz., "S" eggs, or seconds, must weigh less than $1\frac{1}{2}$ oz (Fig 9.)

Cheese.—Post-war consumption of cheese merely indicates that the cheese at present available to people of moderate incomes is of a quality which simply does not attract, for in 1949 the weekly rate of cheese passing into civilian consumption

Table 11

SUMMARY OF FOOD SUPPLIES PER HEAD PER WEEK MOVING INTO CIVILIAN CONSUMPTION IN THE UNITED KINGDOM, 1945-1949

Compiled from data in *Food Consumption Levels*, H.M.S.O., 1949

	oz per head per week (except milk and eggs)					
	Pre-war Average 1934-38	1945	1946	1947	1948	1949 (Prov.)
Dairy Products (excluding butter)						
Liquid milk (pints)	3 30	4 75	4 73	4 60	4 90	5 11
As percentage of pre-war (milk, pints)	100	144	142	140	148	154
Cheese . .	2 71	2 98	3 10	2 85	2 55	2 58
Evaporated milk .	0 74	0 55	1 32	1 17	0 77	0 77
Condensed milk .	3 04	0 77	0 74	0 70	0 78	1 07
Dried whole milk .	0 18	0 34	0 40	0 49	0 46	0 40
Dried skim milk .	0 31	0 74	0 31	0 52	0 15	0 12
As percentage of pre-war (milk solids)	—	130	129	127	128	132
Meat						
Beef—bone in .	16 27	8 99	10 15	9 80	12 80	9 95
Beef—bone out .	0 52	1 07	3 10	3 08	1 66	1·17
Mutton and lamb .	7 74	7 88	7 46	7 44	7 00	6 48
Pork .	3 53	3 44	1 01	0 31	0 31	0 43
Offals .	2 27	1 72	1 72	1 66	1 72	1 62
Canned corned meat	0 64	1 07	1 96	2 05	1 16	1 23
Other canned meat .	0 25	1 50	2 24	1 50	0 67	0 74
Bacon and ham	8 30	5 16	4 64	3 10	3 35	3 22
Total (edible weight)	33 65	26 60	27 60	25 20	22 65	24 00
As percentage of pre-war . . .	—	79	82	75	67	68
Fish (fresh, frozen, cured and canned) .	8 22	7 54	9 20	9 50	9 80	9 18
As percentage of pre-war . . .	—	92	112	115	120	112
Eggs						
(*a*) Shell eggs, No .	3 1	1·80	1 90	1 90	2 40	2 60
As percentage of pre-war (*a*) . .	—	57	61	61	77	83
(*b*) Shell egg equivalent of shell, dried and liquid eggs, No.	3 43	3 70	3 13	3 00	3 06	3 15
As percentage of pre-war (*b*) . .	—	109	91	87	89	92

TABLE 11 (*contd.*)

	oz per head per week (except milk and eggs)					
	Pre-war Average 1934-38	1945	1946	1947	1948	1949 (Prov)
Oils and Fats						
Butter	7 61	2 61	3 35	3 44	3 84	3 84
Margarine	2 67	5 25	4 64	4 58	5 39	5 52
Lard	2 82	3 10	2 45	2 44	2 45	2 93
Edible oils and fats	2 52	1 62	1 30	1 41	1 53	1 69
Total (fat content)	13 91	11 35	10 65	10 43	11 67	12 46
As percentage of pre-war	—	82	77	75	84	97
Sugar and Syrups						
Sugar	31 9	21 67	23 20	24 55	24 90	26 45
Jam and marmalade (imported)	0 03	0 31	0 27	0 83	0 77	0 79
Honey	—	0 13	0 09	0 10	0 19	0 22
Glucose	2·20	1 02	0 95	1 08	0 98	1 05
Total (sugar content)	33 8	22 75	24 30	26 10	26 40	28 00
As percentage of pre-war	—	67	72	77	78	83
Potatoes	54 15	80 00	86 50	87 50	74 30	81 60
As percentage of pre-war	—	148	160	161	138	151
Fruit						
Fresh tomatoes	3 20	2 70	3 10	4 51	4 04	4 70
Fresh citrus fruits	8 75	4 53	4 02	6 20	7 31	6 12
Other fresh fruit	15 15	6 48	11·51	14 93	14 27	13 81
Canned fruit (not citrus)	3 13	0 03	0 73	1 29	1 41	1 69
Total (fresh equivalent)	43 3	27 00	33 70	40 25	40 40	39 50
As percentage of pre-war	—	64	78	94	94	91
Vegetables	33 00	39 00	35 60	35 00	35 30	35 60
As percentage of pre-war	—	118	108	106	107	108
Grain Products						
Flour	59 60	74 00	67 80	68 00	71 60	71 25
Total gains	64 5	79 20	73 00	73 80	76 80	77 00
As percentage of pre-war	—	123	113	114	119	114
Beverages						
Tea, coffee, cocoa	4 52	4 21	4 82	4 68	4 06	4 15
As percentage of pre-war	—	91	107	103	90	92

was 2·58 ounces compared with the pre-war figure of 2·71 oz. per head per week. In 1938 the amount of cheese produced in the United Kingdom was 43,000 tons; in 1950 it was 55,120 tons; for imported cheese the figures are 146,400 tons and 153,600 tons respectively for these years. (Tables 11 and 12.)

TABLE 12

THE AMOUNTS OF CHEESE, BUTTER AND MARGARINE PRODUCED AND CONSUMED IN THE UNITED KINGDOM, AND THE AMOUNT OF CHEESE AND BUTTER IMPORTED INTO THE UNITED KINGDOM FROM 1938 TO 1949 IN THOUSANDS OF TONS PER YEAR

From *Monthly Digest of Statistics*, Central Statistical Office, London, 1951

	Home Produced			Imported		Consumed		
	Cheese	Butter	Margarine	Cheese	Butter	Cheese	Butter	Margarine
1934–38			182 00			184 08	501 80	185 12
1938	43 16	20 28	208 32	146 4	476 4			
1945	22 36	7 80	406 12			231·92	183 04	423 80
1946	24 96	10 92	329 68			217 36	236 60	336 44
1947	16 64	6 76	353 08	190 8	216 0	210 60	242 32	348 92
1948	25 48	8 32	399 36	157 2	272·4	188 24	273 00	400 44
1949	32 28	10 40	420 16	213 6	318 0	221 00	304 20	413 92
1950	55 12	16 12	372 84	153 6	334 8	227·76	372 84	386 36

Butter, Margarine and Lard.—During the years 1942, 1943 and 1944, the consumption of butter had fallen from the pre-war rate of 7 61 oz. per head per week to 2·33 oz. per head per week, a 70 per cent decrease. Throughout the post-war period consumption slowly increased to *3 84 oz.* per head per week, 50 per cent of the pre-war amount. This loss in butter was offset by a phenomenal increase in margarine consumption which had doubled by 1944 and, apart from a slight decline during 1946–47, was well maintained at the 200 per cent level in 1949 and 1950. Lard consumption has been fairly constant at about 3 oz. per head per week. These figures are shown in the amounts of butter and margarine home produced and imported. (Tables 11 and 12 and Fig. 10.)

Meat.—Previous to the war, meats were consumed approximately according to the following pattern: beef 41 per cent, mutton and lamb 20 per cent, pork 10 per cent, bacon and ham

20 per cent, the balance being made up of offal and canned meats. The general pattern did not greatly change until 1944 when the amount of pork coming into general consumption rose well above the pre-war level and then in the following years fell very steadily and reached very low levels during the post-war period, 1947 showing the lowest figures recorded for many years, namely, 8·7 per cent of the pre-war amount. In 1948, the proportion of meats eaten was: beef 44 per cent, mutton and lamb 26 per cent, pork 1·7 per cent, bacon and ham 18 per cent. (See Table 11 and Fig. 7.)

Bacon.—The bacon ration, which had been maintained at 2 to 4 oz. per head per week during 1945–47, varied in 1948 and in January 1949 it reached the low figure of 1 oz. per head per week for about a month, after which it was restored to 2 oz. In August 1949, the ration was raised to 3 oz and in October, for a period of four weeks, it was raised to 4 oz. These changes were due to the fact that bacon is a highly perishable commodity and cannot be stored safely for more than 4 or 5 weeks. The 4 oz. ration per head of the population per week means that

per year. In 1938 home production of bacon and ham was 161,720 tons, the amount imported was 376,800 tons. During the war the amount of bacon and ham passing into civilian consumption fell slightly, but not until 1947 did the supply reach its lowest figure, 3·1 oz per head per week. During 1948 there was little if any improvement in the situation but 1949 showed a marked improvement which continued throughout 1950. In 1950, because of increased imports from Canada, the ration was raised on two occasions for a few months to 5 oz. per head per week. (See Tables 13 and 14.)

The "meat" situation as it has developed during the post-war period, with the year 1938 as a pre-war standard, is shown in Tables 13, 14 and 15, where the figures for the home production and importation of meats (i e. beef, veal, mutton and lamb, pork, offal) and bacon and ham are given.

The pre-war rate of total meat consumption including bacon and ham was 131·7 lb. per head per annum; this is calculated as carcase weight, the equivalent edible weight being 109·6 lb. It is the former, the carcase weight equivalent, which is used in

referring to the total tonnages of meat produced or imported. A point not infrequently overlooked in comparing pre- and post-war food consumption levels is that the population of the United Kingdom has increased from 47·76 millions in 1938 to 49·92 millions in 1950 Were the consumption of meats and bacon and ham what it was in 1938, namely 131·7 lb. per head per

TABLE 13

YEARLY HOME PRODUCTION OF MEAT IN THE UNITED KINGDOM (TONS × 10³)

From *Monthly Digest of Statistics*, Central Statistical Office, London, 1951

Year	Beef	Veal	Mutton and lamb	Pork	Offal	Bacon and ham
1936	618 8	26 0	192 4	176 8	109 2	174 2
1937	587 6	20 8	192 4	176 8	104 0	155 4
1938	580 8	26 0	213 2	166 4	109 2	161 7
1944	488 8	31 2	140 4	26 0	83 2	109 2
1945	514 8	36 4	135 2	31 2	88 4	118 6
1946	535 6	36 4	150 8	20 8	88 4	108 2
1947	478 4	31 2	144 4	10 4	83 2	61 9
1948	462 8	26 0	119 6	15 6	78 0	72 3
1949	502 3	26 0	139 9	33 8	93 6	147 1
1950	604 8	29 1	140 2	62 9	100 9	195 0

TABLE 14

A COMPARISON OF THE HOME PRODUCTION AND IMPORTATION OF MEAT (BEEF, VEAL, PORK, OFFAL, MUTTON AND LAMB) AND BACON AND HAM DURING THE POST-WAR PERIOD AND THAT OF 1938 IN TONS PER ANNUM

Compiled from *Monthly Digest of Statistics*, March 1951

	Meats		Bacon and Ham	
	Home Produced	Imported	Home Produced	Imported
1938	1,090,960	1,058,400	161,720	376,800
1946	840,840	—	108,160	—
1948	710,840	837,600	72,280	134,000
1949	795,600	813,600	147,160	139,000
1950	946,920	810,000	195,000	243,600

Table 15

IMPORTS OF MEAT INTO THE UNITED KINGDOM, 1938 and 1948 (METRIC TONS × 10³)

Food and Agriculture Organisation of the United Nations, 1949

Country	Beef			Mutton and lamb			Pork		
	1938	1948	1948 as per centage of 1938	1938	1948	1948 as per-centage of 1938	1938	1948	1938 as per centage of 1948
Argentina	360	192	53 3	45	70	149 0	12	—	—
Brazil	26	—	—	—	—	—	—	—	—
Uruguay .	83	12	36 4	8	1	12 5	—	—	—
Australia	111	83	74 8	96	42	43 8	14	2	14 3
N Zealand	46	66	143 5	187	266	142 2	29	10	34 5
U S A. .	—	—	—	—	—	—	3	—	—
Canada .	1	21	2100 0	—	—	—	—	—	—
Denmark .	—	2	—	—	—	—	—	—	—
Other countries	7	2	28 6	14	11	78 6	2	—	—
	584	378	64 7	350	390	111 4	60	12	20 0

Country	Offal			Canned Meat			Bacon		
	1938	1948	1948 as per-centage of 1938	1938	1948	1948 as per centage of 1938	1938	1948	1948 as per-centage of 1938
Argentina	27	19	70 4	40	17	42 5	2	—	—
Brazil .	4	1	25 0	1	1	100 0	—	—	—
Uruguay	2	1	50 0	11	4	36 4	—	—	—
Australia .	7	9	128 6	4	19	475 0	—	—	—
N Zealand	5	10	200 0	1	3	300 0	—	—	—
U S.A .	—	—	—	—	—	—	—	—	—
Canada .	—	—	—	—	2	—	65	95	146 2
Denmark	—	—	—	—	—	—	172	24	13 9
Other countries	5	1	20 0	9	15	166·7	84	16	19 0
	50	41	82 0	66	61	92 4	321	135	42 1

Miscellaneous meats not included above . 1938, 71 ; 1948, 37.

annum, we should require 119,000 tons of carcase weight equivalent more than in 1938; but the amount of meats and bacon and ham passing into civilian consumption has fallen to 66 per cent of the pre-war figure, a situation, as far as meat supplies are concerned, which cannot be lightly regarded. In terms of yearly tonnages, the position is presented in Table 14.

The total of meats, bacon and ham available for consumption in 1938 was 2,687,880 tons; in 1948, 1,754,720 tons; in 1950 2,195,520 tons. These figures show that in 1948 the supply of these foodstuffs was 65 per cent of the immediate pre-war standard, and that by the end of 1950 it had risen to 82 per cent of that value. The home production of bacon and ham and beef showed a remarkable recovery during the years 1949 and 1950, the 1938 production being exceeded in the case of bacon and ham by 33,280 tons, in the case of beef by 23,920 tons. The amount of bacon and ham imported is still some 33 per cent below pre-war figures; the importation of meats, particularly beef, suffered largely as a result of failure of the United Kingdom and Argentina to reach agreement on the purchase price of carcase meat. Shipments of meat from the Argentine, which ceased in July 1950, were resumed in May 1951, when Argentina agreed on 23rd April 1951 to export to Britain 200,000 tons of carcase meat and offals at the following prices:

Chilled beef . . .	35,000 tons at £146 per ton
"A" quality beef frozen . .	73,000 tons at £126 per ton
"B" quality frozen beef . .	34,000 tons at £118 per ton
Manufacturing beef with bone .	8,000 tons at £95 per ton
Lamb	36,000 tons at £130 per ton
Offals	14,000 tons at £140 per ton

The reasons for the decrease in home production of beef during the war were the reduction in imports of animal foodstuffs, the loss of grasslands ploughed up to grow crops for direct human consumption and priority given to feeding stuffs for cows to the detriment of pigs, which before the war were fed [illegible] cheap imported cereals. During the war there was a [illegible] affected [illegible] eef. The production of mutton and lamb was affected by the loss of grass and arable land, the sheep being driven back on to the unploughable grassland of the hills, their numbers being reduced

accordingly. Another factor, disastrous in the extreme, was the loss of over 4 million sheep due to widespread blizzards in the spring of 1947. Fortunately there are definite signs of recovery in the home production and importation of meats.

With regard to imported beef, the situation is more difficult because foreign exporters wish to sell in the dollar market; the question of Argentine importations of beef is still a vexed and unsettled one. New Zealand, a rich and well-developed pastoral country, has to consider both dairying and meat production; the one may well increase at the expense of the other and it is possible that the present balance between them will be maintained, with the result that an increase in either the one or the other cannot be expected in the near future. Australia seems to offer the greatest possibilities in the furtherance of meat imports to the United Kingdom, since the Overseas Food Corporation and the Queensland Government have agreed to a scheme for the cultivation of coarse grains and sunflowers on some 800,000 acres of grassland in Queensland The coarse grains will be used for animal feedingstuffs and in particular pig food, partly in this country and partly in Australia. In the first few years of the scheme the larger part of the crop will be shipped to this country, but the use of the crop will be decided in the light of commercial and other considerations from year to year. The sunflower seed will be used to produce edible oils for the manufacture of margarine, etc. The scheme aims at doubling Australian export of meats during the next ten years. The comparison of the total meats imported into the the United Kingdom in 1938 and 1948, seen in Table 15, shows clearly the present day position with regard to our importation of meats from Commonwealth and foreign countries. Important in such a table are the countries from which the various meats are imported and the percentage of the total importation which each supplies. The post-war period shows a slight improvement in beef with bone, but the supplies for civilian consumption have remained seriously low since 1942. Such changes as have been referred to here have naturally meant *numerous changes in ration and "points" control of* fresh and canned meats. The meat ration ranged from 8d. to 1s. 8d. worth per head per week during the post-war period. In December 1950 it was reduced to 8d. and in January 1951 it

was raised again to 10d., but reduced to 8d. on 4th February. This, the lowest meat ration ever recorded in this country, was due to a deadlock reached in the negotiations for a new meat agreement between Britain and the Argentine. As a result of the agreement reached, the meat ration was raised to 10d. in April 1951, and, according to the Minister of Food, Mr. Webb, it is expected to go up to 1s. 8d. in August 1951.

Fish.—During the second year of the war the consumption of fish fell from the pre-war rate of 8·22 oz. to 4·60 oz. per head per week. The year 1945 saw a rapid recovery of the industry, and in 1946 the amount of fish—fresh, frozen, cured and canned —available for civilian consumption had increased beyond the pre-war figure. (See Fig. 8.)

Wheat.—Since 1945 the U.S.A. has assumed the leading position so long held by Canada as the world's largest exporter of wheat. This is the result of a succession of record breaking crops since 1944. In the post-war period the Cereals Committee of the International Emergency Food Council has succeeded in establishing international co-operation for the better distribution of available supplies of wheat and other food grains. Unfortunately the work of this Council is made more difficult by the absence of representatives of Argentina and the U.S.S.R. The figures as set out in Table 16 are for the wheat output of major exporting countries.

Wheat production was most unfavourably affected by weather conditions in 1946–47; in contrast to favourable conditions in America, Southern Europe wheat-growing areas were affected by a serious lack of rain in 1946, an extremely severe winter in 1946–47 and a prolonged spell of hot, dry weather which cut yields of grain, reduced output of fodder and burned up pastures. Wheat seed requires a receptive soil in the late autumn and a definite amount of moisture and sunshine; the requirements are well known to all, as are the, at times, inexplicable climatic changes which can so easily affect harvest prospects.

At a meeting of the International Wheat Council in London in December 1947, Canada, U.S.A. and Australia agreed provisionally to export 6259·7, 5035 and 2313 thousand metric tons of wheat respectively. The United Kingdom guaranteed to import 5171 thousand metric tons of wheat grain, including wheat flour of 72 per cent extraction, for the three years ending 1950–51. Home production of wheat varied but slightly

during the years 1945 to 1949, the average amount being just under 1500 thousand tons. By a later International Wheat Agreement which was ratified in 1949, it was agreed that the following countries should export definite annual amounts of wheat over the 4 years 1st August 1949 to 31st July 1953;

TABLE 16

WHEAT OUTPUT OF MAJOR EXPORTING COUNTRIES IN THOUSAND METRIC TONS

From Food and Agriculture Organisation, 1948

Country	Average, 1934–38	Average, 1939–43	1944	1945	1946	1947[1]
Argentina	6,634	6,279	4,085	3,907	5,615	4,763
Australia	4,200	3,946	1,439	3,876	3,720	5,852
Canada	7,170	12,068	11,339	8,669	11,262	9,276
United States	19,476	23,466	28,852	30,161	31,454	38,286
Total	37,480	45,759	45,715	46,613	52,051	58,177

[1] Preliminary

NET EXPORTS OF WHEAT AND FLOUR FOR MAJOR EXPORTING COUNTRIES IN THOUSAND METRIC TONS

Country	Average, 1934–35 to 1938–39	Average 1939–40 to 1943–44	1944–45	1945–46	1946–47
Argentina	3,308	2,855	2,896	1,889	1,684
Australia	2,909	1,669	1,505	1,119	1,283
Canada	4,821	6,577	9,335	9,258	6,602
United States	871	419	3,020	10,581	10,896
Total	11,909	11,520	16,756	22,847	20,465

Australia 2176 thousand metric tons, Canada 5521 6 thousand metric tons, U.S.A. 4569 thousand metric tons, while the United Kingdom agreed to import 4814 thousand metric tons. These quantities were subject to adjustment; for example, Canada's quota is 80 per cent of her current exportable surplus, Australia's is similar, while the United States quota is only one-third of the

annual amount exported in recent years. Much of the United States export will be to Western Europe, the Far and Near East, the Union of South Africa, India and South America.

In view of these facts the post-war production and importation of wheat and other grains can be the more intelligently understood, for they determine the amount of bread available to the nation. War forced us to abandon the 70 to 73 per cent extraction of the wheat berry which gave us the white bread to which we had been so long accustomed. Extraction rates were the source of much unenlightened controversy during the war; the extraction rate is always an approximate figure because in nearly all flour-importing countries the home product, which in Europe varies from 80 to 95 per cent extraction, is blended to a greater or less extent with imported flour of 70 to 75 per cent extraction. In 1944 the extraction rate of the flour from which national bread was made was reduced to 82·5 per cent, being made up of a mixture of home wheat of 85 per cent extraction and a suitable amount of imported white flour. In 1946, because of bad harvests and reduction of imports of wheat, the Minister of Food decided to make greater use of our wheat supplies for direct human consumption by increasing the extraction rate of flour to 85 per cent. This alteration was effected gradually and while it meant a return to the darker war-time loaf, it increased in some measure the nutritive value of our bread. It also led to a reduction in the volume of animal feedingstuffs, a corresponding diminution in livestock in the country and a marked fall in the production of bacon, poultry and eggs in the latter half of 1946. In August 1950, the extraction rate of flour used for the national loaf was again reduced to 80 per cent, the flour being made up of home milled national flour of 81 per cent extraction and a proportion of imported flour of about 70 per cent extraction.

Consumption of Wheat.—Not all the wheat is used for human consumption; in the United Kingdom previous to the war 15 per cent was fed to livestock; during the war it fell to 5 per cent, while for the period of rationing it was illegal to feed flour or bread to livestock.

The main bulk of flour passing into civilian consumption is eaten as bread, including biscuits, cakes, buns and scones. Bread is all important to a beleagured garrison or to an island people dependent upon its importation, for upon its availability

depends the morale of a nation faced with dire peril. That the supply of grain and therefore the consumption of bread never fell below the pre-war amount during the years 1939 to 1945 was a noteworthy achievement. (Fig. 12.)

Bread Rationing.—European countries, hard hit by the disastrous weather conditions of 1946–47, were faced with the prospect of dangerously low bread supplies. Governments, being forewarned, instituted measures to deal with the decline in grain supplies and in the United Kingdom one of these measures was the institution of bread rationing on 21st July 1946. Bread, flour, cakes, buns and scones were rationed in one scheme and measured in Bread Units, more familiarly termed B.U.s., the values being as follows :—

Bread : 1 small loaf, 14 oz. .	2 B U s
1 large loaf, 1 lb 12 oz	4 B U s
Flour · 1 lb —3 B U s, 3 lb	9 B U s
Cakes, buns, scones : ½ lb . .	1 B U
1 lb .	2 B U s

	Coupon Values in B U.s							
	Already in ration book					Extras obtained as below		Total B U.s per week
	L	M	F	J	G	BUx	BUy	
Child under 1 . .	1		1					2
Child 1–5 .	1	2	1					4
Child 5–11 .	1	2		5				8
Adolescent 11–18 .	1	2		5		4		12
Normal adult .	1	2			6			9
Expectant mother	1	2			6			
(incl Green Book)	1		1					11
Manual worker, man	1	2			6	4	2	15
Manual worker, woman	1	2			6		2	11

Coming after the successful conclusion of a world war during which bread supplies had been surprisingly well maintained, the advent of bread rationing was of the nature of a disagreeable shock to national prestige. Much criticism was forthcoming, most of it indicative of a total lack of knowledge of the world factors which made such action imperative. To the higher income groups who eat little bread, bread rationing may have appeared unnecessary, but to those lower income groups for whom bread is a major dietetic consideration, it was

by no means unnecessary. The advantage of the Bread Unit Scheme was that it allowed freedom of choice in that, as far as flour foods were concerned, one could buy whatever one wished anywhere and at any time within a four week period. The table on page 83 shows which were the B.U. coupons in the ration book and how many could be used each week without borrowing from the next week's allowance.

L and M coupons were in all ration books; G coupons were in the general book, J in the blue book (5 to 18 years) and F in the green book (up to 5 years). BUx and BUy coupons were supplied by employers to workers who received the special cheese ration, had no canteen facilities and had therefore to provide packed meals at home. It was also possible to interchange B.U.s and "points" whereby extra bread could be obtained at the expense of "points" foods or alternatively more "points" foods at the expense of bread.

The rationing of bread, flour and flour confectionery and all restrictions on the serving of bread with meals came to an end on 24th July 1948. According to the Minister of Food the scheme had effected the saving of 9000 tons of flour per week in 1946–47 and approximately 6000 tons per week in 1947–48. During the period, to meet variations in the supply of flour, there were several minor adjustments in the allocation of bread units to the several categories shown in the table.

Sugar.—In 1938 approximately 300,000 tons of refined sugar were produced from home-grown sugar beet; during the war the amount so produced was increased so that it virtually maintained the domestic ration of sugar of 8 oz. per head per week which amounted to approximately 550,000 tons of sugar per year. In 1949 the beet sugar industry produced 500,000 tons of refined sugar; the amount of unrefined sugar imported was 2·2 million tons and the amount of refined sugar consumed was 1·93 million tons, this latter figure being 83·5 per cent of the pre-war consumption. Sugar rationing is still in vogue, the ration varying from 8 to 10 oz. per head per week with bonuses for special purposes, such as domestic jam making and for farm workers engaged in harvesting, sheep shearing, etc.

Items of note in Table 11 are the high rate of consumption of potatoes, the position of vegetables in the nation's dietary and the lack of an adequate supply of fresh citrus fruits.

Potatoes.—In 1941 the consumption of potatoes had risen to 156 per cent of the pre-war figure, and continued to increase until 1947, when the figure fell from 161 to 134 per cent of pre-war. This was due to a 20 per cent fall in the potato crop occasioned by wet weather in the spring and abnormally dry weather in the summer of 1947. The full effect of this loss in supply would not be felt until the following year and in order that all supplies should be fairly shared and to prevent the country running out of potatoes before the next harvest a scheme of rationing was adopted and put into effect in November 1947. Under this scheme the normal allowance was 3 lb. per head per week; children under 5 years of age could obtain 1½ lb., expectant mothers 4½ lb. per week, special allowances were made for catering establishments and non-residents in institutions and for young people between 5 and 18 years of age living at home. As a result of an excellent response from the public, by the careful planning of potato imports and an extremely good season for new potatoes in 1948, the rationing of potatoes came to an end on 1st May 1948 (Fig. 12.)

It is well known that the people of Great Britain responded with considerable zeal to the call of the Minister of Food in 1941 to grow more potatoes and vegetables in their gardens and allotments In 1942 there were 1½ million allotments under cultivation and an unknown number of gardens were being stripped of flowers and plants that food may be grown. It is estimated that by these means domestic production in 1942 was 500,000 tons of potatoes and over one million tons of other vegetables. Gardens and allotments do not readily permit of a "rotation of crops" even if they be but potatoes and a limited number of vegetables; it is therefore not surprising if there be a falling off in this type of domestic production; indeed the indiscriminate production of potatoes should not be encouraged but a limited growing of one's own vegetables in gardens and allotments is highly desirable. (Fig 11.)

Calories and Nutrients.—With 3000 Calories as a pre-war standard, the energy value of the war and post-war diet has shown a remarkable constancy indicated by the amount of food going into civilian consumption (Tables 11 and 17) and by the results of numerous dietary surveys.

Protein.—Animal and vegetable protein have remained almost stationary at 43 g. and 47 g. per head per day respectively

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The rationing of bread, flour and flour confectionery and all restrictions on the serving of bread with meals came to an end on 24th July 1948. According to the Minister of Food the scheme had effected the saving of 9000 tons of flour per week *in 1946–47 and approximately 6000 tons per week in 1947–48.* During the period, to meet variations in the supply of flour, there were several minor adjustments in the allocation of bread units to the several categories shown in the table.

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Calories and Nutrients.—With 3000 Calories as a pre-war standard, the energy value of the war and post-war diet has shown a remarkable constancy indicated by the amount of food going into civilian consumption (Tables 11 and 17) and by the results of numerous dietary surveys.

Protein.—Animal and vegetable protein have remained almost stationary at 42 g. and 47 g. per head per day respectively

throughout the five years from 1944, giving a total protein intake of 89 g. per head per day. This favourable position is due to the increase in milk consumption and improved fish supplies and should in the near future be enhanced by a greater importation of meat. The fear, oft expressed during the war, that a fall in animal protein would be injurious to health has not materialised although, because of the low animal protein ration for adolescents, it was not without justification.

Table 17

NUTRIENT EQUIVALENT OF SUPPLIES PER HEAD PER DAY MOVING INTO CIVILIAN CONSUMPTION IN THE UNITED KINGDOM

From *Food Consumption Levels in the United Kingdom*, H.M S O , 1949

	Pre war	1945	1946	1947	1948	1949 (provisional)
Protein —						
Animal g	42 7	42 1	44 3	43 0	41 1	40 7
Vegetable g.	37 2	47 2	46 0	47 7	46 4	47 5
Total	79 9	89 3	90 3	90 7	87 5	88 2
Fat from all sources g.	130 2	116 0	112 0	105·4	107 6	110 0
Carbohydrate . g	377 0	383 2	376 8	391 2	394 1	408 8
Calcium mg	693	1,047	1,078	1,190	1,106	1.216
Iron . mg	12 4	14 6	17 1	16 6	15 7	15 8
Vitamin A . i u	3,997	3,771	3,727	3,840	3,915	3,920
Ascorbic acid mg	96	107	107	112	111	113
Vitamin B_1 . mg	1 2	1 8	1 9	1 8	1 8	1 8
Riboflavin mg	1 6	1 8	2 0	2 0	1 9	2 0
Nicotinic acid mg	13 4	14 8	17 0	14 9	14 2	14 3
Energy value— Calories .	3,000	2,930	2,880	2,880	2,890	2,980

Fat.—As a nutrient the position of fat is the most serious of all. Table 17 shows a fall from 130 2 g. per head per day, the pre-war figure, to 116 0 g. in 1945 and a further fall to 105 4 g. in 1947. Today the figure is still below the lowest war level of 1941 (113·4 g.). At a later stage the comparative values of the chief sources of fat in terms of Calories and protein will be

discussed, but, as a general statement, it would appear that to secure improvement in our national diet the chief requirement is an increase in the consumption of butter, beef and pig meat.

Calcium.—In 1942 flour was fortified by the addition to the 280 lb. sack of flour of 7 oz. of calcium carbonate; in 1946 an additional 7 oz. were added. These additions, with the increased rate of extraction of flour, are responsible for the marked increase in the calcium intake

Iron.—The iron content of flour has varied between 1 7 and 2 8 mg. per 100 g. The increased consumption of iron has been due to the change in the extraction rate of flour and the increased consumption of potatoes and canned meats which was at its highest in 1946–47.

Vitamins.—The intake of these nutrients has shown a remarkable constancy over a period of years, the only variation, which was of a temporary nature, being the rise in nicotinic acid towards the end of 1946 when, due to an increase in the flour extraction rate from 85 to 90 per cent, the nicotinic acid content of flour rose from 1·7 to 3 6 mg. per 100 g. In 1947, vitamin A and D tablets, issued to expectant mothers under the Welfare Foods Service, were enriched by the addition of 0·13 mg. potassium iodide, the action being based on a recommendation of the Medical Research Council.

NATIONAL FOOD SURVEYS

The broad picture presented of foods moving into civilian consumption can give no accurate indication of the nutritional adequacy of these foods as diets. For this purpose the results of dietary surveys must be consulted and compared with generally accepted standards.

The data of national surveys such as those of the Ministry of Food and the Ministry of Health may be compared with standards published by the United States National Research Council for 1945 populations, or with standards calculated from the nutrient requirements of the families taking part in the survey. This latter is perhaps the more accurate in that a standard is arrived at for the particular community surveyed. For general purposes the estimated daily nutrient requirements of the population in the United Kingdom in 1948—weighted average requirements based on the National Research Council

throughout the five years *from* 1944, *giving a total protein* intake of 89 g. per head per day. This favourable position is due to the increase in milk consumption and improved fish supplies and should in the near future be enhanced by a greater importation of meat. The fear, oft expressed during the war, that a fall in animal *protein would be injurious to health has* not materialised although, because of the low animal protein ration for adolescents, it was not without justification.

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From *Food Consumption Levels in the United Kingdom*, H M S O., 1949

	Pre war	1945	1946	1947	1948	1949 (provisional)
Protein :—						
Animal g	42·7	42·1	44·3	43·0	41·1	40·7
Vegetable g.	87·2	47·2	46·0	47·7	46·4	47·5
Total	79·9	89·3	90·3	90·7	87·5	88·2
Fat from all sources g	130·2	116·0	112·0	105·4	107·6	110·0
Carbohydrate . g	377·0	383·2	376·8	391·2	394·1	408·8
Calcium mg	693	1,047	1,078	1,190	1,106	1.216
Iron . mg.	12·4	*14·6*	*17·1*	*16·6*	15·7	15·8
Vitamin A i u	3,907	3,771	3,727	3,840	3,915	3,920
Ascorbic acid . mg	96	107	107	112	111	118
Vitamin B_1 . mg	1·2	1·8	1·9	1·8	1·8	1·8
Riboflavin . mg	1·6	1·8	2·0	2·0	1·9	2·0
Nicotinic acid mg	13·4	14·8	17·0	14·0	14·2	14·3
Energy value— Calories .	3,000	2,930	2,880	2,880	2,890	2,980

Fat.—As a nutrient the position of fat is the most serious of all. Table 17 shows a fall from 130·2 g. per head per day, the pre-war figure, to 116·0 g. in 1945 and a further fall to 105·4 g. in 1947. Today the figure is still below the lowest war level of 1941 (113·4 g.). At a later stage the comparative values of the chief sources of fat in terms of Calories and protein will be

Table 18 represents the data obtained by the Ministry of Food surveys of the food consumption in the homes of urban working-class families for the years 1942 to 1947; Table 19 shows the amounts of the various nutrients obtained from these diets. The figures denoting the amount of food consumed per head per week in a family do not agree accurately with those of the amounts of food per head per week moving into civilian consumption; the consumption of food in a family group or in

TABLE 19

MINISTRY OF FOOD NATIONAL FOOD SURVEY

(*Report of the Committee on Nutrition*, B.M A., London, 1950)

Nutrient Content of Food Consumed in the Home—Urban Working-Class Households

	Average Intake per head per day						
	1941 (*a*)	1942 (*a*)	1943	1944	1945	1946 (*b*)	1947 (*b*)
Calories . .	2,339	2,269	2,272	2,387	2,375	2,307	2,308
Protein :—							
Total . gm	73	74	73	73	76	78	77
Animal . gm	29	34	32	35	35	37	36
Fat . . gm			86	94	92	86	82
Carbohydrate gm			300	311	310	303	315
Calcium . mg.	605	672	855	868	873	912	996
Iron . . mg	12 4	13 5	13 3	13 5	12 7	14 4	14 3
Vitamin A . i u	3,170	2,982(*c*)	3,071	3,173	2,908	3,112	3,148
Vitamin B :—							
Thiamine mg	1 18	1 40	1 53	1 62	1 47	1 55	1 52
Riboflavin mg	1 40	1 54	1 64	1 76	1 58	1 65	1 64
Nicotinic acid . mg.	11 9	11·9	12 7	13 9	13 2	14 5	12 9
Vitamin C (*d*) mg	76	76	83	87	86	89	80
Vitamin D . i u	95	100	112	106	143	174	169

(*a*) Nutrient intake has been calculated from quantities of food consumed except for 1941 and part of 1942, when only details of foods purchased were available The figures for these periods have been adjusted by making an allowance for the effect of this factor on each nutrient

(*b*) The sample in 1947 covered only the first three-quarters of the year. Welfare Vitamin Foods were included in 1946 and 1947, but not in previous years

(*c*) March–December 1942, only

(*d*) No allowances have been made for cooking losses The average for 1947 would have been higher had the fourth quarter been covered, although still lower than in 1946

allowances for 1945—may be taken as a good practical standard; they are :—

Calories	Protein g	Calcium mg	Iron mg	Vitamin A I U.	Thiamine mg	Riboflavin mg	Nicotinic acid mg	Vitamin C mg
2560	65	910	12	4650[1]	1 3	1 7	13	71

[1] In order to compare the vitamin A of the standard with that of the intakes shown in the dietary survey in Table 18, the amount of performed vitamin A, namely 2580 I U should be substituted (Cmd 7842, 1949).

Table 18

MINISTRY OF FOOD NATIONAL SURVEY

(*Report of the Committee on Nutrition*, B.M A., London, 1950)

Food Consumption in the Home—Urban Working-Class Households
(in ounces per head per week, except where otherwise stated)

Food (a)	1942	1943	1944	1945	1946	1947 (b)
Fats—Total	8 64	8 73	9 19	8 63	8 23	7 89
Butter and margarine	6 13	6 18	6 34	6 35	6 29	6 25
Sugar and preserves—Total	13 34	13 90	15 11	14 61	14 97	15 66
Sugar	8 41	8 71	9 05	9 13	9 55	10 15
Milk—Total (equiv pints)	3 78	4 30	4 41	4 43	4 31	4 37
Liquid (pints)	3 50	3 94	3 97	4 11	3 95	3 96
Cheese	3 58	3 07	2 61	2 49	2 54	2 26
Eggs—Total (equiv number)	1 40	2 22	2 93	3 01	2 50	2 30
Shell (number)	0 92	0 83	0 94	1 27	1 41	1 60
Meat and Meat Products —						
Rationed meat and offals	15 33	15 75	16 14	15 93	16 36	16 27
Bacon and ham	3 95	4 03	4 55	3 54	3 22	2 20
Rabbit, poultry, game, etc	0 99	0 89	1 07	0 96	0 82	0 58
Cooked and canned meats	1 99	1 71	2 42	2 06	2 05	2 33
Sausages (uncooked)	3 99	3 78	4 11	3 87	4 18	4 12
Fish—Total	6 61	6 54	7 61	9 21	10 55	9 54
Fresh and processed	4 94	4 46	5 25	6 71	8 03	7 08
Potatoes (incl chips)	68·46	71 17	71 34	68 50	73 81	70 78
Other Vegetables—Total	31 85	34 47	37 31	36 32	34 57	30 77
Fresh	28 80	31 72	34 41	32 47	30 49	25 91
Fruit (incl tomatoes)—Total	12 32	12 76	14 00	15 94	15 68	21 73
Fresh	9 48	10 70	11 67	13 83	13 56	19 07
Cereals—Total	81 51	83 29	/83 29	85 44	82 47	83 83
Bread and flour	67 94	66 56	67 00	67 98	68 05	67 89

(a) Beverages and a few miscellaneous foods, e g, soups, extracts, salad dressings, have been excluded.

(b) In this year the sample covered only the nine months January–September.

cattle. So effective and far reaching were the activities of the Ministry of Food that by 1943 about 90 per cent of all food bought for civilian consumption was subject to some form of price control. Importation, home production, distribution and price of food were further linked with a system of food rationing which began on 1st January 1940 and for which the ration books were printed in 1938. The aim of this great piece of official administration was to ensure a fair share to all of available food supplies, to stabilize the cost of living and to avert the danger of inflation.

These activities were well justified, for they played no small part in maintaining the morale of the people when faced with serious losses of food by sea and land and the rising cost of buying and shipping food from abroad. In the year from June 1940 to June 1941, just over one million tons of food and feeding-stuffs, 7 per cent of the total shipped, were lost at sea; and from October 1942 to March 1943, when imports had been reduced 30 per cent, 400,000 tons, 9 per cent of imported food, were lost by U-boat action. From air attack throughout the war 309,000 tons of foodstuffs were destroyed, of which 159,000 tons were lost between September and December 1940.

Shipping losses meant drastic cuts in the food supplies to a civilian population, with men and women fully employed, receiving high wages and showing a very marked increase in its purchasing power. Had no steps been taken to control this purchasing power, the prices of food would have risen, resulting in a bad distribution of food to the poorer sections of the community, the demand for wage increases would have been stimulated and thus the vicious spiral of inflation would have started. Herein lay the reason for the early introduction of schemes of price control, rationing and taxation of surplus purchasing power. In April 1941 the Chancellor of the Exchequer, Sir John Anderson, decided to stabilize the Cost of Living Index by holding down the retail price of certain foods by means of subsidies. At this time, the Cost of Living Index was 25 to 30 per cent above the pre-war level; this position was maintained throughout the war On 1st August 1945 the Index of Retail Food Prices was 25 per cent higher than it was in September 1939; this figure is in marked contrast to the 130 per cent rise in food prices during the 1914–1918 war. In 1947, as a result of an investigation into the factors upon which the cost of

a community is determined by the number, age and occupation of its members, and also by whether the family or community is urban or rural. Calories are difficult to assess because children, especially young children in a family, reduce the number of Calories required for the group. Apart from the Calories, a comparison of the intake of nutrients shown in Table 19 with requirements stated for 1948 populations show that in the years 1940 and 1941 there was a deficiency of animal protein, calcium and vitamins of the B group. In the first half of 1941 the supplies of animal protein and fat in working-class groups were 33 g. and 105 g. per head per day respectively. For the remainder of the war and during the post-war period up to 1949, animal protein, carbohydrate, calcium, iron and vitamin C showed a very satisfactory improvement. In these nutrients, as also in the B group of vitamins, our diet is equal to or above the pre-war standard. The outstanding lack in the diet of to-day is fat; while there has been a continued improvement in the diet of all classes since the dangerous days of 1940–41, due largely to better extraction of grain, increased importation of fruits and a greater consumption of milk and milk products, much still remains to be done to lessen the monotony and unpalatability of the British diet, especially that of the lower income groups.

CONTROL OF FOOD PRICES AND FOOD SUBSIDIES

For the facts and figures upon which this section is based I am indebted to the Finance General (Home) Division of the Ministry of Food.

The 1914–18 war had shown how vulnerable the United Kingdom was with respect to its food supplies; experience of the past emphasized the importance, in any future emergency, of the need for supervising imports, regulating distribution and controlling the price of food and feedingstuffs. On September 1st 1939, steps were taken to hold provisionally the price of certain foods at the then existing levels and bring the importation of the more important foods under the control of the Ministry of Food. By the end of the year a wide range of foodstuffs was under price control—meat, flour, butter, margarine, cooking fats, eggs, cheese, sugar, dried fruits, oil seeds, canned foods, animal feedingstuffs and pigs, sheep and fat

The method of subsidization was to make direct payment to producers or traders, or for the Ministry of Food to take the loss on official trading operations. In the case of milk, meat,

TABLE 20

EFFECT OF SUBSIDIES ON RETAIL PRICES

1946

	Current Retail Price (as used in Cost of Living Index)			Price if not Subsidized		
	s	d		s	d	
Bread	1	9	per 4 lb	1	1	per 4 lb
Flour	1	3	per 6 lb	1	9½	per 6 lb
Oatmeal		3½	per lb		5	per lb
Meat (home killed)	1	0¾	per lb	1	4¼	per lb.
Bacon	1	10½	per lb.	1	11	per lb.
Potatoes		7	per 7 lb		10¾	per 7 lb
Eggs (large)	2	0	per doz	3	6½	per doz
(small)	1	9	per doz	3	3½	per doz.
Sugar (domestic)		4	per lb		6	per lb
Milk		9	per quart		10	per quart
Cheese	1	1	per lb.	1	4	per lb
Tea	2	10	per lb	3	0	per lb.

1947

Food	Retail Price at 1st April 1947	Retail Price that would have to be charged without Subsidy	Annual Cost to Exchequer, £ millions
Milk	*9d a quart*	*11d a quart*	61 4
Eggs—Large	2/- per dozen	3/8 per dozen	21 7
Small	1/9 per dozen	3/5 per dozen	
Potatoes	7½d per 7 lb	1/0½ per 7 lb	26 5
Flour	1/5½ per 7 lb	2/5¾ per 7 lb	77 2
Bread	10½ per 4 lb	1/4½ per 4 lb	
Butter	1/6 per lb	2/3½ per lb	26 0
Margarine—Standard	9d per lb	1/1½ per lb	3 1
Special	5d per lb	9½d per lb	
Bacon	1/10½ per lb	2/4¾ per lb	16 7
Cheese	10d per lb	1/6½ per lb	23 4
Tea	2/10 per lb	3/9 per lb	3 1
Sugar	4d per lb.	7d. per lb	24 3
Meat (average cuts)	10¾d per lb	1/2¼ per lb	53 0
Miscellaneous — Mainly animal feedingstuffs and fertilizers			61 4

living index was based, the Minister of Labour decided to insti tute a new interim Index of Food Prices, 100 being taken as th Index on 17th June 1947. This interim Index is still (195C in use, and the latest figures issued by the Ministry of Labou show that, at 13th December 1949, the " all items " Index wa 113, the Food Retail Price Index 120.

Food Subsidies.—When the Government's decision to con tinue to hold down retail prices by the use of public funds wa first announced, subsidies were being paid at the rate of abou £50 million a year. The cost has risen progressively since then as the following table shows :—

	1939–40 £m	1940–41 £m	1941–42 £m	1942–43 £m	1943–44 £m
Total cost of subsidies .	13 2	63 1	95 7	142 6	182 5

	1944–45 £m	1945–46 £m	1946–47 £m	1947–48 £m	1948–49 £m
Total cost of subsidies	195 7	265 5	325	391	484 4

	1949–50 (estimate) £m	1950–51 (provisional) £m
Total cost of subsidies .	*462 6*	*410*

The effects of subsidies on the retail prices of the principal food in 1945, 1947 and 1949–50 are shown in Table 20.

In the House of Commons on 3rd November 1949, th Chancellor of the Exchequer gave the following figures to shov the current annual rate of payments made to subsidize importec and home-produced food :—

	£m
To reduce the cost of imported foods . .	183 5
To reduce the cost of home-grown foods . .	211 3
To reduce the cost of imported feedingstuffs .	33 8
To reduce the cost of home-grown feedingstuffs .	2 9
Acreage payments	16 1
Fertilizers	15 0
	£m 462 6

In his budget speech the Chancellor of the Exchequer, Si Stafford Cripps, announced that " measures would be taken tc prevent subsidies from exceeding £465 million in the yeai 1949–50 ". In his budget speech of 1950 he announced that [illegible]

as to raise prices . (House of Commons [illegible])

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EFFECT OF SUBSIDIES ON RETAIL PRICES

1946

	Current Retail Price (as used in Cost of Living Index)			Price if not Subsidized		
	s	d.		s	d.	
Bread	1	9	per 4 lb	1	1	per 4 lb
Flour	1	3	per 6 lb	1	9½	per 6 lb
Oatmeal		3½	per lb		6	per lb
Meat (home killed)	1	0½	per lb	1	4½	per lb
Bacon	1	10½	per lb.	1	11	per lb.
Potatoes		7	per 7 lb		10½	per 7 lb
Eggs (large)	2	0	per doz	3	6½	per doz
(small)	1	9	per doz	3	3½	per doz
Sugar (domestic)		4	per lb		6	per lb
Milk		9	per quart		10	per quart
Cheese	1	1	per lb.	1	4	per lb
Tea	2	10	per lb	3	0	per lb

1947

Food	Retail Price at 1st April 1947	Retail Price that would have to be charged without subsidy	Annual Cost to Exchequer, £ millions
Milk	9d a quart	11d a quart	61 4
Eggs—Large	2/- per dozen	3/8 per dozen	21 7
Small	1/9 per dozen	3/5 per dozen	
Potatoes	7½d per 7 lb	1/0½ per 7 lb	26 5
Flour	1/5½ per 7 lb	2/5½ per 7 lb	77 2
Bread	10½ per 4 lb	1/4½ per 4 lb	
Butter	1/6 per lb	2/3½ per lb	26 0
Margarine—Standard	9d per lb	1/1½ per lb	3 1
Special	5d per lb.	9½d per lb	
Bacon	1/10½ per lb	2/4½ per lb	16 7
Cheese	10d per lb	1/0½ per lb	23 4
Tea	2/10 per lb	3/9 per lb	3 1
Sugar	4d per lb.	7d per lb	24 3
Meat (average cuts)	10½d per lb	1/2½ per lb	53 0
Miscellaneous — Mainly animal feedingstuffs and fertilizers			61 4

TABLE 20 (*contd.*)

1949–50

DETAILS OF FOODSTUFFS AT PRESENT SUBSIDIZED AND THE ESTIMATED 1949–50 RATE OF EACH SUBSIDY

Commodity	Unit	Estimated Subsidy 1949–50 £m	Current Average Retail Price per Unit	Subsidy per Unit	Price per Unit if no Subsidy
			s d	s d.	s d.
Bacon	per lb	30 2	2 3	1 2	3 5
Bread (*a*)	per 3½ lb. loaf (*c*)	64 1	0 11	0 6	1 5
Flour (*a*)	per 7 lb.	35 5	1 9	1 1½	2 10½
Shell eggs	per dozen	30 7	3 0	1 3¼	4 3¼
Carcase meat	per lb	40 8	1 5	0 3	1 8
Milk	per quart	51 3	0 10	0 2½	1 0½
Butter (*b*)	per lb	53 3	1 6	1 6	3 0
Cheese (*b*)	per lb.	25 2	1 2	1 0¾	2 2¾
Margarine	per lb	16 0	0 10	0 4½	1 2½
Lard and domestic cooking fat	per lb	5 6	1 0	0 3½	1 3½
Potatoes (*a*)	per 7 lb	14 7	0 10	0 2	1 0
Sugar	per lb	8 1	0 5	0 1	0 6
Tea	per lb	15 0	3 4	0 8½	4 0½
Fish		4 0			
Sundries	Credits	32 2			
		362 3			
Welfare Foods:					
Milk in Schools		9 0			
National Milk Scheme		22 0			
Vitamin Foods and National Dried Milk		6 1			
Animal Feedingstuffs		36 7			
Fertilizers		15 0			
Loss on potatoes bought under guarantee		11 5			
		462 6			

(*a*) Includes acreage payments.
(*b*) Includes subsidy on manufacturing milk.
(*c*) Includes £8 4 m subsidy payable to bakers

eggs, sugar, butter, cheese, oils and fats, bacon, tea and animal feedingstuffs, almost the entire supply is bought by the Ministry or its agents at some stage of sale, either to control supplies for

TABLE 20 (*contd.*)

1950–51

DETAILS OF FOODSTUFFS AT PRESENT SUBSIDIZED AND THE ESTIMATED 1950–51 RATE OF EACH SUBSIDY

Commodity	Unit	Estimated Subsidy 1950–51 £m	Current Average Retail Price per Unit	Subsidy per Unit	Price per Unit if no Subsidy
			s d	s. d	s d
Bacon	per lb.	38 2	2 5	1 0¼	3 5¼
Bread	per 3½ lb. loaf	55 3	0 11	0 5½	1 4½
Flour	per 7 lb	33 9	1 9	1 1	2 10
Shell eggs	per dozen	26 3	3 0 to 3 10	1 0	4 0 to 4 10
Meat	per lb	40 1	1 5	0 2¼	1 7¼
Milk	per quart	72 0	0 10	0 2¾	1 0¾
Butter	per lb	40 2	1 10	1 0¼	2 10¼
Cheese	per lb.	18 9	1 2	0 9¼	1 11¼
Margarine (domestic)	per lb.	14 0	0 10	0 4	1 2
Lard and domestic cooking fat	per lb	4 7	1 0	0 2¾	1 3¾
Potatoes	per 7 lb	15 4	say 10½[1]	0 2	1 0½
Sugar (domestic)	per lb	10 1	0 5	0 1¼	0 6¼
Tea	per lb	17 3	3 4	0 9	4 1
Welfare foods		37 6			
Sundries	*Credit*	14 0			
		410 0			

[1] Not applicable to end of season conditions.

rationing or to save manpower and transport in marketing The price to the consumer is therefore subsidized by direct payments; to producers of rye and potatoes on the basis of acreage planted; and to flour millers and bakers on records of throughput and costs of production.

The purchase method of subsidization is naturally the more simple. Differences in the prices of imported and home-produced foods are evened out and remuneration of processors and traders arranged by varying the Ministry's selling price according to the service to be performed by the buyer. The

other method involves calculating the rate of subsidy payable on completion of detailed returns by traders, a system of check tests to verify their claims and a good deal of office work in handling claims and payments.

Since subsidies must ultimately be reduced, the price control will be lifted as supplies improve. In 1950 control of prices and marketing ceased for new potatoes, carrots, oranges, grapefruit, poultry and rabbits, and fish, with the exception of the sales for kippering.

The great bulk of essential foods is still controlled and will remain so for some considerable time. It is necessary, if the nutritional level of the nation is to be maintained and improved, that all essential foods should be freely available to every man, woman and child in whatever social class they may find themselves, and to this end there must be not only fortification of flour, welfare services and special priorities, but food rationing firmly linked to price control. These things must be; difficulties associated with finance, food production, changing world markets and diminished supplies of essential foods make it imperative that no change in control of price or ration should be effected which would deprive any of a fair share of the available food. Nutrition or physical and mental well-being is not merely a function of nutrients but of appetizing food and of acceptable social conditions; where there is no equitable relationship between the cost of living, the price of food and a man or woman's basic wage the State is still in a condition of economic imbalance, and nutritional deficiencies will still continue to exist among its citizens.

During this difficult period of post-war readjustment, much has been done to increase the supply of foods produced and imported, to improve their nutritional value and to secure a better economic distribution. The devastation of war, with the disappearance of old and the creation of new markets, has forced many governments to look for the solution of their nutritional problems on the wider basis of international co-operation. By its support of agreements entered into with the Dominions, the U.S.A., Scandinavian and other countries for the control and regulation of world production and distribution of foodstuffs, the government of the United Kingdom has declared its adherence to the belief that only by concerted international action can the major problems of world nutrition be solved.

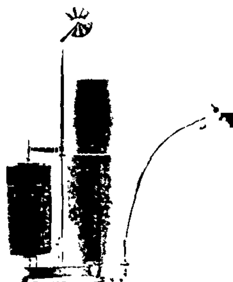


FIG 13.—The Roth-Benedict apparatus.

[*To face page* 97.

CHAPTER VI

THE ENERGY REQUIREMENTS OF THE BODY

The body requires energy in order to grow, to create heat, to make good wear and tear and to do work.

All energy is expressed as heat or work, and in the human body it is derived from the oxidation of carbon, hydrogen, nitrogen, sulphur and other elements of which the foodstuffs are composed. The foodstuffs cannot be used directly as sources of energy but are reduced by the process of digestion to certain soluble forms which permit of their easy transference across the wall of the intestine into the blood-stream and so to the various tissues of the body in forms appropriate to their use. In the processes of digestion, work is performed in the alimentary tract, and the amount of work done will depend on the nature of the foods to be digested. Some of the soluble substances will be reconstituted in the various parts of the body to form muscle, bone, nerve and other tissues; some will be utilized to supply the energy for the rebuilding and maintenance of the tissues. If after a period of twelve hours when no food has been taken and therefore no absorption is taking place, the amount of energy expended by the body be measured, an exact record is obtained of the irreducible minimum of energy necessary to keep the body alive, that is, to maintain its temperature, the action of the heart, the movements of respiration and the resting activity of glands (liver, kidneys, thyroid, pituitary, etc.). This is known as the basal metabolic rate, or the B.M.R. The amount of work performed outside the body varies greatly according to circumstances and may amount to from one-third to three-fourths of the total energy output of the body. The great variations in external energy production depend upon the general activity and the occupation of the individual, and such variations are in marked contrast to the constancy of the basal metabolism. This means that the greater the amount of muscular work done the greater must be the amount of food consumed.

Heat is produced in the resting body by the oxidation of foodstuffs and by the tonic activity of the musculature of the

body, and in the event of work being carried out, a greater amount of heat will be produced. In this respect the body is essentially a machine. A locomotive has a thermal efficiency of 10 to 15 per cent, an internal combustion engine 20 per cent, a Diesel engine about 40 per cent. *The human body varies in* its efficiency according to the conditions under which work is performed. Much depends upon training, the type of work, adaptability to the task, the onset of fatigue, etc. The average efficiency of the human machine may be taken as 20 per cent; the maximum is probably not over 35 per cent: that is to say, of the total amount of oxygen utilized, 35 per cent is used to produce work, the remaining 65 per cent to produce heat. The body, like an engine, obeys the law of the conservation of energy, which states that no energy is ever created or destroyed; therefore the total output of energy by the body is the sum total of the energy derived from the fuel stores within the body and from food ingested. But the analogy between the body and an engine must not be pushed too far, for there are essential differences, the most important of which are that the body never stops working, the oxidations within the muscle take place during recovery following contraction, any depletion of fuel is immediately made good and fuel material is used for tissue repair.

The Determination of Energy or Fuel Values.—In experiments upon foodstuffs the large Calorie is used. This is equal to 1000 small Calories and is designated "Cal." or "kcal." (kilo-calorie); the definition of the large Calorie is "*the amount of heat required to raise 1000 grams of water from 15° C to 16° C*". The amount of heat which is given off when any foodstuff is burned may be measured in a bomb calorimeter of known capacity. Into it a weighed amount of a sample is placed in an atmosphere of oxygen, the calorimeter is tightly closed, and the substance is burned by electrical ignition. When carbohydrate, fat or protein is burned, the amount of oxygen utilized, the carbon dioxide, water and heat produced can be measured accurately. Each foodstuff has its own characteristic heat of combustion. Thus glucose liberates 3·74 Cal. per gm., glycogen 4·3 Cal. per gm., fats average 9·5 Cal. per gm. and proteins 5·6 Cal. per gm. In the body, protein liberates only 4·2 Cal. per gm. because it is incompletely burned, there being a loss of nitrogen chiefly as urea and ammonia in

the urine; consequently a certain amount of energy is lost and a correction must be made for it. Carbohydrate and fat, on the other hand, are as completely oxidized in the body as they are in the calorimeter.

Calorific Value of Oxygen and Respiratory Quotient.—In these experiments with the bomb calorimeter one notes a definite relationship between the amount of oxygen utilized and the heat produced; this is called *the calorific value of oxygen* and is always stated in terms of 1 litre (1000 c c.) of oxygen. For glucose the value is 5 Cal., for starch or glycogen it is a little more, for fat it is 4 7 Cal. while for protein it is 4 5 Cal. There is further, a relationship between the volume of carbon dioxide produced and the volume of oxygen utilized when these three classes of foodstuffs are oxidized This as a ratio $CO_2 : O_2$ is called *the respiratory quotient* and is written thus

$$\frac{\text{Vol. of } CO_2}{\text{Vol. of } O_2} = \text{R Q.}$$

For carbohydrate the respiratory quotient is 1, because, when burned, the volume of oxygen utilized is accurately balanced by the volume of carbon dioxide produced; for fat it is 0 7 because fat contains very little oxygen, which must consequently be provided in sufficient amounts to oxidize the hydrogen and carbon in the fat molecule; for protein it is 0 82. As a result of the experimental work upon which these facts are based, it is now possible, knowing the oxygen utilization, carbon dioxide production and nitrogen excretion of an individual, to determine the amounts of carbohydrate, fat and protein which have been burned over a definitely determined period of time. For the details of the methods and calculations by which this is determined one must have recourse to a textbook of physiology.

Estimation of the Basal Metabolic Rate.—In the examination of the energy output or basal metabolism of patients in hospitals the methods referred to would be impracticable, and fortunately it is possible to arrive at very accurate results by indirect methods. This is indirect calorimetry and all that it requires is the accurate estimation of the oxygen used by the subject over short intervals of 6, 10 or 15 minutes, using the Benedict-Roth apparatus. The principle of this apparatus for the estimation of basal metabolism is shown in Fig 14, while the apparatus itself is shown in Fig. 18

The individual, having fasted for 12 to 14 hours, breathes pure oxygen, and all exhaled carbon dioxide (CO_2) is absorbed by soda lime. The oxygen utilized is indicated by the fall in the spirometer bell which is calibrated so that the amount of oxygen removed per millimetre drop in the bell is known. Thus from the fall in the oxygen line over a period of six minutes, see Fig. 15, one can calculate the energy expended in terms of Calories per square metre of body surface per hour. In charts supplied for the calculation of the B.M.R. the oxygen line in millimetres is equal to Calories per square metre per hour. For this rapid method of estimation the calorific value of oxygen is taken as 4·825 Calories per litre and the spirometer bell has a diameter of 16·5 cm. and therefore a factor of 20·73 c.c. per mm. This gives 1 mm. = 20 73 × 4·825 = 0·100 Calories: if for a period of 6 minutes the O_2 line shows a fall of 80 mm. then 80 × 0 1 × 10 = 80 Calories per hour. To estimate the body surface of a subject, one may use the formula of Du Bois where $A = W^{0.425} \times C$ or, $\log A = (\log W \times 0.425) + (\log H \times 0.725) + \bar{3}.8564$, where A = surface area in square metres, W = weight in kilograms, H = height in centimetres and C = a constant = 0 007184. More conveniently the area is obtained by the use of a nomogram such as shown in Fig. 16, or from Table 21 where weight is related to surface area in square metres for different heights.

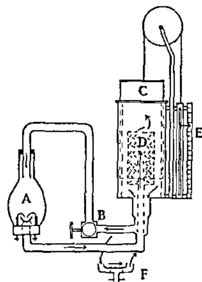
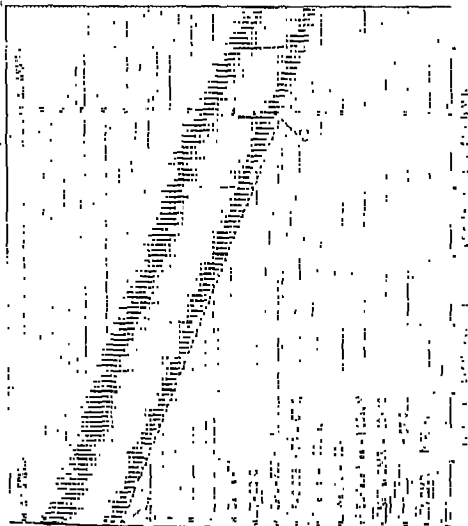
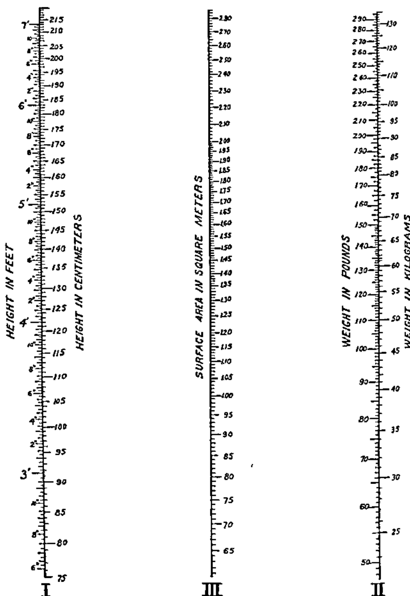


FIG 14—Diagram of oxycalorimeter for determining energy values of foods, etc.
(A) Combustion chamber for nickel crucible and electrical connections (B) Rotary blower. (C) Spirometer bell with oxygen in water seal. (D) Soda lime container (E) Scale in millimeters for measuring the oxygen used (F) Mouth-piece with valves for B M R estimation (enlarged)
Principle of the Benedict-Roth apparatus for determining B M R is seen by replacing A and B by F.

The basal metabolic rate is always stated as a percentage of





Draw a straight line through the appropriate points on columns I (Height), and II (Weight) Read the Surface Area where the line intersects column III

FIG 16 —Du Bois chart for computing surface area of the body from height and weight as prepared by Boothby and Sandiford of the Mayo Clinic.

the normal for an individual of the age and surface area of the subject examined. As an example: it is known that for an adult man 25 years of age, the B.M.R. is 40 Calories per square metre per hour.

TABLE 21

SURFACE AREA IN SQUARE METRES FOR DIFFERENT HEIGHTS AND WEIGHTS

Weight in Kilograms

Height cm.	25	30	35	40	45	50	55	60	65	70	75	80	85	90
200								1 91	1 97	2 03	2 09	2 15	2 21	2 26
195							1 80	1 87	1 93	1 99	2 05	2 11	2 17	2 22
190						1 70	1 77	1 84	1 90	1 96	2 02	2 08	2 13	2 18
185					1 60	1 67	1 74	1 80	1 86	1 92	1 98	2 04	2 09	2 14
180				1 40	1 57	1 64	1 71	1 77	1 83	1 89	1 95	2 00	2 05	2 10
175			1 36	1 46	1 53	1 60	1 67	1 73	1 79	1 85	1 91	1 96	2 01	2 06
170		1 26	1 34	1 43	1 50	1 57	1 63	1 69	1 75	1 81	1 86	1 91	1 96	2 01
165	1 14	1 23	1 31	1 40	1 47	1 54	1 60	1 66	1 72	1 78	1 83	1 88	1 93	1 98
160	1 12	1 21	1 29	1 37	1 44	1 50	1 56	1 62	1 68	1 73	1 78	1 83	1 88	1 93
155	1 09	1 18	1 26	1 33	1·40	1 46	1 52	1 58	1 64	1 69	1 74	1 79	1 84	1 89
150	1 06	1·15	1 23	1 30	1 36	1 42	1 48	1 54	1 60	1 65	1 70	1 75	1 80	
145	1 03	1 12	1 20	1 27	1 33	1 39	1 45	1 51	1 56	1 61	1 66	1 71		
140	1 00	1 09	1 17	1 24	1 30	1 36	1 42	1 47	1 52	1 57				
135	0 97	1 06	1 14	1 20	1 26	1 32	1 38	1 43	1 48					
130	0 95	1 04	1 11	1 17	1 23	1 29	1 35	1 40						
125	0 93	1 01	1 08	1 14	1 20	1 26	1 31	1 36						
120	0 91	0 98	1 04	1 10	1 16	1 22	1·27							

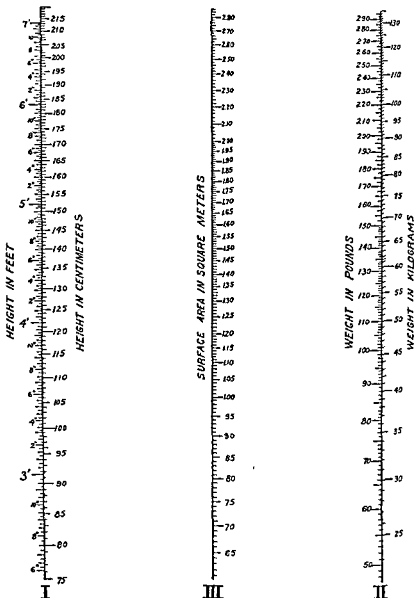
Weight = 70 kg. or 154 lb.
Height = 170 cm. or 68 inches.
Surface area = 1 8 square metres.
The O_2 line or Calories per hour = 96 mm.
Correction factor for normal temperature and pressure = 0 8.
The B.M.R. = 96 × 0 8 = 76 8 Cals. per hour.

The normal B M.R. for a person 25 years of age, having a surface area of 1 8 sq. m. is 40 × 1·8 = 72 Cals. per hour.

The B.M.R. of the subject expressed as a percentage of the normal (72) = 6 6

The basal metabolism for 24 hours = 76 8 × 24 = 1843 Cals.

Convenient though this method of expressing the basal metabolic rate as a percentage of the normal is, nevertheless it may be misleading unless the actual heat production is



Draw a straight line through the appropriate points on columns I (Height), and II (Weight). Read the Surface Area where the line intersects column III

FIG 16 —Du Bois chart for computing surface area of the body from height and weight as prepared by Boothby and Sandiford of the Mayo Clinic.

the [illegible]
su[illegible] it is known that for an ad[illegible] years of age, the B.M.R. is 40 Calories per square metre per hour.

TABLE 21

SURFACE AREA IN SQUARE METRES FOR DIFFERENT HEIGHTS AND WEIGHTS

Weight in Kilograms

Height cm.	25	30	35	40	45	50	55	60	65	70	75	80	85	90
200														
195														
190														
185														
180														
175														
170														
165														
160														
155														
150														
145														
140														
135														
130														
125														
120														

Weight = 70 *kg. or 154 lb.*
Height = 170 cm. or 68 inches.
Surface area = 1·8 square metres.
The O_2 line or Calories per hour = 96 mm.
Correction factor for normal temperature and pressure = 0·8.
The B.M.R. = 96 × 0·8 = 76·8 *Cals. per hour.*

The normal B.M.R. for a person 25 years of age, having a surface area of 1·8 sq. m. is 40 × 1·8 = 72 Cals. per hour.

The B.M.R. of the subject expressed as a *percentage* of the normal (72) = 6·6.

The basal *metabolism* for 24 *hours* = 76·8 × 24 = 1843 Cals.

Convenient though this method of expressing the basal metabolic rate as a percentage of the normal is, nevertheless it may be misleading unless the actual heat production is

calculated. This is particularly true when dealing with obese subjects because the heat increase is proportional to the surface area and, in the obese subject, the surface area is not normal for the age of the subject. Such a subject may be producing far more heat than that produced by a normal subject of the same age and sex.

Table 22 gives the height, weight and surface area of males and females from 1 to 25 years of age.

TABLE 22

HEIGHT, WEIGHT AND SURFACE AREA OF CHILDREN AND ADOLESCENTS

Age years	Males					Females				
	Height		Weight		Surface Area in sq metres	Height		Weight		Surface Area in sq metres
	in.	cm.	lb	kg.		in.	cm	lb.	kg	
1	30	76	22	10	0 50	30	76	20	9	0·50
2	33	84	27	12	0 57	33	84	26	12	0 57
3	38	95	33	15	0 64	38	95	33	15	0 64
5	42	107	41	18	0 72	42	107	40	18	0 71
8	49	124	54	24	0 92	48	122	51	23	0 88
11	55	140	70	32	1·12	54	137	71	32	1 10
12	57	145	77	35	1 20	57	145	80	36	1 22
13	59	150	86	39	1 28	60	152	90	41	1·32
14	61	155	97	44	1 38	61	155	100	45	1 40
15	64	162	111	50	1 51	63	160	108	49	1 48
16	66	168	122	55	1 61	64	162	115	52	1 54
18	68	172	134	61	1 72	65	165	124	56	1 60
20	69	175	140	64	1 76	66	168	130	59	1 65
25	69	175	147	67	1·82	66	168	133	60	1 67

The Basal Metabolic Rate and Total Energy Requirements of Children and Adolescents.—In the new-born child the basal metabolic rate is low, approximately 30 Calories per square metre per hour, but it rises quickly until at six months it is about 50 and at twelve months 55 Calories per square metre per hour. The maximal rate, 53 to 57 Calories per square metre per hour, is reached in the second year (see Table 23 and Fig. 17). The high rate in infancy is due to the rapid growth of the child, particularly in respect of the growth of muscle and the development of muscle tone. It is

the period of change from the helpless, muscularly inactive infant to the would-be helpful, intensely active and alert child. It is a period of growth in which the central nervous system is keeping pace with a rapidly increasing musculature, a period in which the finer interrelation of brain tissue with muscle activity is fully developed and is evidenced by the development of

TABLE 23

COMPARISON OF BASAL AND TOTAL METABOLIC RATES OF MALES AND FEMALES

Compiled from Boothby, Bergson and Dunn, *Amer J Physiol*, 116, 1936

Age	B.M.R. Calories per sq metre per hour		Total Basal Metabolism[1] Calories per 24 hours		Total Calories per day (U.S.A.)	
	Males	Females	Males	Females	Males	Females
Birth	30	30	288	298	440	440
1	55	52	660	624	1000	1000
2	57	53	780	725	1200	1200
3	55	52	845	798	—	—
5	53	52	915	880	1600	1600
8	51.8	47.0	1143	993	2000	2000
11	47.2	45.2	1268	1193	2500	2500
12	46.8	43.3	1347	1267	—	—
13	46.5	42.0	1428	1330	—	—
14	46.4	41.5	1537	1391	3200	2800
15	46.0	40.0	1667	1420	—	—
16	45.7	38.8	1764	1434	3500	2800
18	43.2	37.5	1783	1440	3600	2500
20	41.6	36.3	1756	1437	3500	2400
25	40.3	36.0	1760	1442	3000	2400
40	38.0	35.0	1641	1344	3000	2400

Pregnancy (latter half) 2400 Calories per day
Lactation 3000 Calories per day

[1] Total basal metabolism = B.M.R./sq. m./24 hr. × surface area in sq. m.

postural tone, balancing mechanisms and numerous physiological adaptations. There is then a steady falling off in the intensity of metabolism up to the fifth year, and a slower decline through later childhood, followed by a slight increase in activity as puberty is reached. Metabolic activity is then continued with a slow, steady deceleration throughout the period of adolescence. While in adults all that is necessary is to maintain

a normal weight by an intake of food, the energy value of which balances the energy requirements of the body, in children the question of growth must receive careful attention. Growth, in normal children, is always associated with great muscular activity, and the intake of food must be increased in order that it may adequately balance basal metabolism, muscular activity and growth. A rapidly growing child may utilize up to 15 per cent of the energy value of its food for growth alone; this represents the extra energy utilized to build up new tissue. In childhood and adolescence variations in the basal metabolic rate of 10 to 15 per cent are quite normal. From the results of numerous investigations Tables 22 and 23 have been compiled. They show the general average for the height in inches and centimetres, the weight in pounds and kilograms, and the surface area in square metres, the daily basal metabolic and total energy requirements in Calories for ages 1 to 25 years. The last column of figures for Calories per day in Table 23 are the recommended daily amounts published by the National Research Council, Washington, U.S.A. (1948) and represent the energy requirements of normal persons of moderate activity. The most important fact indicated in Table 23 is the great increase in the total metabolic needs of children and adolescents between the ages of 8 and 18 years.

The facts so far presented are graphically represented in Fig. 17. The growth curves for boys and girls show a divergence first at about 10 years of age when girls, on an average, grow a little more rapidly than boys with the result that, at about 13 years of age, girls are about 3 to 4 lb. heavier and may even be taller than boys of that age. Interesting at this latter age is the marked difference in the total basal expenditure of energy between boys and girls. Boys from 14 until about 18 to 20 years of age, continue to increase their total metabolism, girls, on the other hand, after 16 years, remain almost at a constant figure. The factor at play, and it may by no means be the only factor, is the relation between the rate and extent of growth of the body and its changing surface area.

If one considers the matter further and compares the total energy requirements of boys and girls in relation to those of their fathers and mothers respectively, assuming naturally that the parents are normal and are at leisure, one is impressed by the need of adolescents.

In Fig. 18 the total energy requirements of male children and adolescents are shown as a percentage of the normal *sedentary* parent (2400 Cals.) The upper curve shows clearly how the energy needs of the boy between 11 and 18 years exceed those of his father. At 10 years they are almost equal,

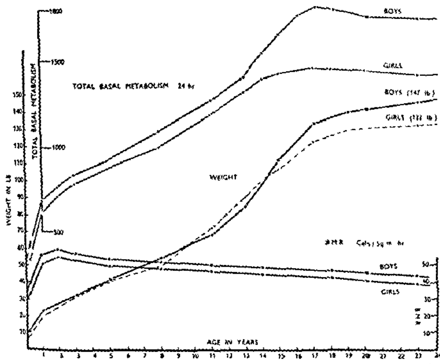


FIG. 17 —Curves of basal metabolism in 24 hours, weight, and basal metabolic rate for ages 1 to 24 years

at 11 years they are 4 per cent greater, at 14 years they are 33 per cent greater and at 18 years 58 per cent greater than the sedentary adult male with an energy output of 2400 Calories. The dotted line in this chart shows the adolescent girl's requirements as a percentage of those of her father. In Fig. 19, the adolescent girl is compared with her mother, whose *sedentary* energy output is 2000 Calories. One important fact emerges, namely, that the daughter has a calorific need, which, when she

a normal weight by an intake of food, the energy value of which balances the energy requirements of the body, in children the question of growth must receive careful attention. Growth, in normal children, is always associated with great muscular activity, and the intake of food must be increased in order that it may adequately balance basal metabolism, muscular activity and growth. A rapidly growing child may utilize up to 15 per cent of the energy value of its food for growth alone; this represents the extra energy utilized to build up new tissue. In childhood and adolescence variations in the basal metabolic rate of 10 to 15 per cent are quite normal. From the results of numerous investigations Tables 22 and 23 have been compiled. They show the general average for the height in inches and centimetres, the weight in pounds and kilograms, and the surface area in square metres, the daily basal metabolic and total energy requirements in Calories for ages 1 to 25 years. The last column of figures for Calories per day in Table 23 are the recommended daily amounts published by the National Research Council, Washington, U.S.A. (1948) and represent the energy requirements of normal persons of moderate activity. The most important fact indicated in Table 23 is the great increase in the total metabolic needs of children and adolescents between the ages of 8 and 18 years.

The facts so far presented are graphically represented in Fig. 17. The growth curves for boys and girls show a divergence first at about 10 years of age when girls, on an average, grow a little more rapidly than boys with the result that, at about 13 years of age, girls are about 3 to 4 lb. heavier and may even be taller than boys of that age. Interesting at this latter age is the marked difference in the total basal expenditure of energy between boys and girls. Boys from 14 until about 18 to 20 years of age, continue to increase their total metabolism, girls, on the other hand, after 16 years, remain almost at a constant figure. The factor at play, and it may by no means be the only factor, is the relation between the rate and extent of growth of the body and its changing surface area.

If one considers the matter further and compares the total energy requirements of boys and girls in relation to those of their fathers and mothers respectively, assuming naturally that the parents are normal and are at leisure, one is impressed by the need of adolescents.

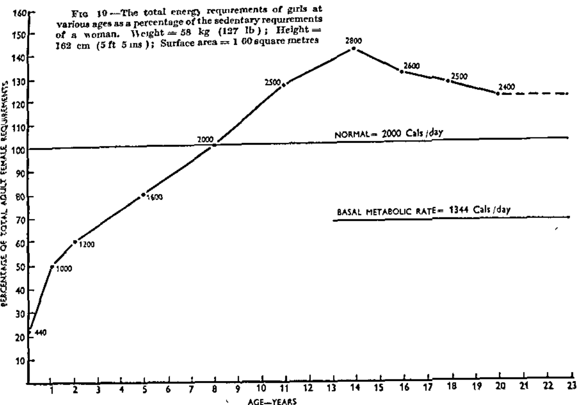


FIG 10.—The total energy requirements of girls at various ages as a percentage of the sedentary requirements of a woman. Weight = 58 kg (127 lb); Height = 162 cm (5 ft 5 ins); Surface area = 1 60 square metres

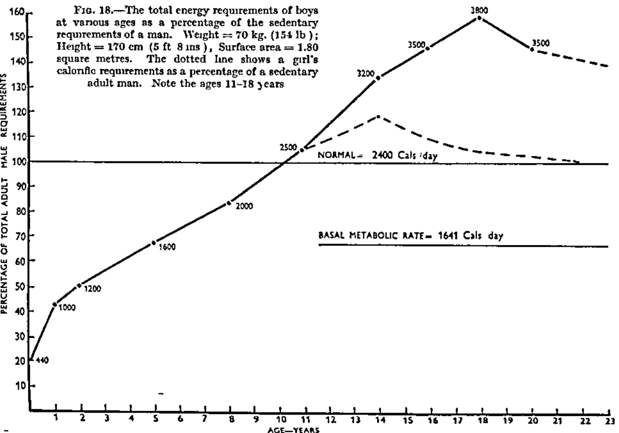


FIG. 18.—The total energy requirements of boys at various ages as a percentage of the sedentary requirements of a man. Weight = 70 kg. (154 lb); Height = 170 cm (5 ft 8 ins), Surface area = 1.80 square metres. The dotted line shows a girl's calorific requirements as a percentage of a sedentary adult man. Note the ages 11–18 years

is absorbed by soda lime in metal containers through which the expired air passes. These are carried by the subject with the bag, if a race is being run, or placed with the bag by his side if stationary exercise is carried out. Such an experiment will give a figure for oxygen utilization from which the increased metabolism for the time of the exercise can be calculated. From such experiments are obtained figures which show, for the period of exercise, the effect which swimming, dancing or rowing, etc., etc., have in increasing metabolism Now for children and adolescents, whose activities are too varied to be correctly tabulated and accurately measured there is only one method which, if carried out over sufficiently long periods, gives fairly accurate information as to the energy expenditure day by day and that is to measure periodically the actual food consumption day by day for a week. This method has been very fruitful in results. From a sample of all the meals taken each day, dried and burned in the bomb calorimeter or by a careful dietary survey, the calorific value of the food is determined. The weight and height of the child are accurately recorded at intervals during the period and if the growth curve is normal and the children dietetically satisfied, then it is accepted that the Calories taken as food have been sufficient to supply the energy requirements and maintain normal growth.

FACTORS AFFECTING METABOLISM

The conditions which determine energy needs are the amount of active tissue in the body, the intensity of the activity within these tissues and the work done by the body in promoting growth, maintaining repair and in meeting all the demands made upon its musculature in the routine tasks of everyday life. Several major considerations which add to the energy requirements of the body are age, sex, occupation, the mode of life and the temperature of the body. Certain special conditions which may be noted are pregnancy and lactation, fevers due to infectious disease and endocrine deficiency disease. The active tissues of the body are the muscles and all glands; structures such as bones, arteries and nerves have a very limited metabolism compared with the glandular tissues. The muscles, the liver, the salivary, gastric and intestinal glands and the endocrine organs are the seat of chemical processes by which

is 8 years old, is equal to that of her mother, and when 14 years old, is 40 per cent greater.

The question may arise as to how these Calorie requirements are determined, in view of the fact that they are associated with great and varying outputs of activity.

TABLE 24

TABLE GIVING AN APPROXIMATE IDEA OF CALORIE VALUES

In Terms of Domestic Amounts of some Common Foods

	Calories
Milk, one glass (8 oz)	150
One tablespoonful of butter (0 5 oz)	*100*
Cream, one tablespoonful (1 oz)	60
Ice cream, ½ cup	100
One egg	75
Cheese, 1-inch cube (1 0 oz.)	100
Meat, lean, 1 oz. (cooked)	70
Meat, average fatty (1 oz.)	100
Liver (stewed) (1 oz.)	60
Bacon, slices, four average (156 Cals /oz)	100
Sausages, two average sized	100
Fish, fatty, e g herring (2 oz)	100
sardines (2 oz) (canned)	160
Sugar, two tablespoonfuls (1 oz)	100
Jam, syrup, honey, etc , 1 tablespoonful (1 oz)	80
Rice (1 oz)	100
Potatoes, one medium sized, boiled (4 oz)	80
Cereals, ½ cup (2 oz) (e g oatmeal)	220
Oatcake (1 oz)	100
One thick slice of bread (1 5 oz)	100
One banana or orange, average size	75
One apple or pear, average size (approx. 4 oz)	50
Dates, five medium size (1½ oz)	100
Prunes (1½ oz dried or 2½ oz cooked)	60
Raisins, ½ cup (1½ oz)	100
Orange or grape fruit juice, 1 cup	100
Figs, dried (1 oz)	60
Chocolate, plain (1 oz)	150

Numerous studies have been made of the increase, over basal metabolism, occasioned by different forms of exercise. Many of these investigations have been carried out by the method of indirect calorimetry, in which oxygen is inhaled from a Douglas bag carried by the subject, and the CO_2 produced

is absorbed by soda lime in metal containers through which the expired air passes These are carried by the subject with the bag, if a race is being run, or placed with the bag by his side if stationary exercise is carried out. Such an experiment will give a figure for oxygen utilization from which the increased metabolism for the time of the exercise can be calculated. From such experiments are obtained figures which show, for the period of exercise, the effect which swimming, dancing or rowing, etc., etc., have in increasing metabolism. Now for children and adolescents, whose activities are too varied to be correctly tabulated and accurately measured there is only one method which, if carried out over sufficiently long periods, gives fairly accurate information as to the energy expenditure day by day and that is to measure periodically the actual food consumption day by day for a week. This method has been very fruitful in results. From a sample of all the meals taken each day, dried and burned in the bomb calorimeter or by a careful dietary survey, the calorific value of the food is determined The weight and height of the child are accurately recorded at intervals during the period and if the growth curve is normal and the children dietetically satisfied, then it is accepted that the Calories taken as food have been sufficient to supply the energy requirements and maintain normal growth.

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The conditions which determine energy needs are the amount of active tissue in the body, the intensity of the activity within these tissues and the work done by the body in promoting growth, maintaining repair and in meeting all the demands made upon its musculature in the routine tasks of everyday life. Several major considerations which add to the energy requirements of the body are age, sex, occupation, the mode of life and the temperature of the body. Certain special conditions which may be noted are pregnancy and lactation, fevers due to infectious disease and endocrine deficiency disease. The active tissues of the body are the muscles and all glands; structures such as bones, arteries and nerves have a very limited metabolism compared with the glandular tissues. The muscles, the liver, the salivary, gastric and intestinal glands and the endocrine organs are the seat of chemical processes by which

energy is transformed from the food into heat and work. And not only into that work which is apparent and can be accounted for, but into those invisible activities whereby digestive juices are formed for dealing with ingested food, external secretions are elaborated for controlling assimilation and utilization of the products of digestion, and internal secretions are produced for the regulation of all those chemical changes upon the correct interrelation of which the health and well-being of the body depends.

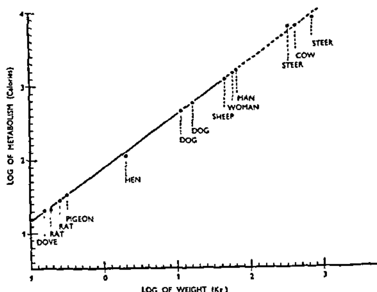


FIG. 20.—Showing linear relationship between log of metabolism and log of body weight. (Kleiber, 1932)

Body Size and Surface Area.—One of the factors which determine basal metabolic needs is the amount of tissue in the body; smaller animals expend much less energy than large ones but the increase in energy with size is not directly proportional to the body mass or weight. A straight line relationship between the two can be obtained by plotting the logarithm of the weight in kilograms against the logarithm of metabolism in Calories. The result of this is shown in Fig. 20

Growth.—This factor must be considered in any discussion of energy exchange of different individuals because the basal metabolism of the individual changes with growth and maturity. Growth determines the size and the weight of the body; it is a period of rapid increase in tissue and of the storing of reserves of chemical energy. It is for this reason, as will be seen later, that children and adolescents require as much as or more food than their parents.

The amount of active tissue in the body, the intensity of the activity within these tissues and growth are so interrelated in children and adolescents that it is well to consider both basal metabolic rate and total energy requirements of these groups as a whole.

Sex.—Another factor which affects basal metabolism is sex; the basal metabolic rate of the female, infant and adult, is some 5 to 10 per cent less than that of the male.

The Effect of Food on Metabolism.—Food serves as a source of energy and makes good wear and tear; if in excess of immediate needs, carbohydrate is stored in the form of glycogen or animal sugar, chiefly in the liver and muscles; fat in the normal physiological state is stored in fat depôts. During the period of its digestion each foodstuff, be it protein, carbohydrate or fat, causes a characteristic amount of heat to be produced: this fact was discovered by Rubner in 1885 and called by him "the specific dynamic action" (S.D.A.) of the food; for protein it may amount to some 20 to 30 per cent of the calorific value of the protein ingested; for fat and carbohydrate the amount is much less, being of the order of 5 to 6 per cent. Specific dynamic action is evidence that the body can use its own reserves more efficiently than it can use the foodstuffs supplied, to prevent a simultaneous oxidation of body tissue the calorific value of the protein must be one-fourth to one-third greater than the basal energy exchange during the time that the foodstuffs are being oxidized. It should be noted that this extra heat is not available for work, it merely adds to the heat of the body and shows the value of protein in the diet of peoples living in cold climates

The effect of overfeeding upon the energy metabolism of man has been studied with conflicting results. Some have reported a rise of 4 to 5 per cent in the basal metabolic rate when a high intake of energy is accompanied by a high protein intake (Kleitman, 1926); others have stated that no changes

are occasioned by surfeit feeding. This latter finding is supported by Munro (1950), who has shown that, if to a normal diet giving 2850 Calories, there be added daily 680 Calories, in the form of meat, milk, lactose and butter (protein, 36 g.; fat, 39 g.; carbohydrate, 46 g.) for 15 days, no change occurs in the B.M.R. Hamilton (1939), who investigated factors affecting basal metabolism in growing rats, could find no causal relation between basal metabolism and the protein of the diet or the rate of growth of the animal.

The Effect of Muscular Work on Metabolism.—It is known that in a resting condition with food, about 77 per cent of the body heat is lost by radiation and conduction, 21 per cent by evaporation of moisture from the skin and the lungs and 2 per cent by urine and fæces. When a measured amount of work is done, equal, as in the following Table, to 550 Calories, then the total energy expenditure rises to 5130 Calories, the percentage dissipation of which by radiation and conduction is 74, by urine and fæces 0 6, by the evaporation of moisture from the skin and lungs 14·7, as work 10 7. The excess metabolism over the resting metabolism with food is 5130 − 2400 = 2730 Calories: this represents the energy which must be produced in order that the body may perform work equal to 550 Calories.

HEAT LOST IN CALORIES BY

	Radiation and Conduction	Urine and Fæces	Evaporation, Lungs and Skin	Active Work	Total Calories
Resting with food . .	1850 (77 %)	28 (2 %)	522 (21 %)	—	2400
Work with food	3800 (74 %)	30 (0 6 %)	750 (14 7 %)	550 (10 7 %)	5130

The mechanical efficiency of the body in doing this work is

$$\frac{\text{work}}{\text{excess metabolism}} = \frac{550}{2730} = 20 \text{ per cent.}$$

The Effect of Fever on Metabolism.—In a high environmental temperature, e g. 100° F. in the shade, the humidity of the air does not interfere markedly with perspiration and there will be practically no change in the body temperature. If, however, there be no loss of heat by evaporation of moisture from the skin or by radiation or conduction as in a very high

relative humidity, e.g. 90 per cent, the body temperature will rise and with it an increase in oxygen utilization. For every degree Fahrenheit that the body temperature is raised there is a 7 per cent increase in basal metabolism which in the adult may be equal to 120 Calories. It is always a problem for the physician to determine in febrile cases just how much of the extra expenditure of energy should be met by increased food. A judicious prescribing of diet must accompany very skilful nursing in all highly febrile cases

Under conditions of lowered external temperature, the body conserves heat by diminishing the blood supply to the skin, reducing perspiration and produces it by shivering, that is, by increasing the fine tonic contraction of muscles. It requires temperatures below 25° C. to produce any definite change in basal metabolism of a nude person When the body temperature has fallen from the normal 37·5° C. or 98 6° F. to 15° C. or 59° F shivering may be sufficient to double the basal metabolic rate

Effect of Pregnancy.—During pregnancy there is little or no gain in weight until after the sixth week, but thereafter there is a steady increase up to the thirty-ninth week. According to Stander and Pastore (1940) the range in weight increase is large, but the average increase in 3000 cases examined was 14 kg. (= 30 lb.) which represented an increase over the non-pregnant weight of 24 per cent From this weight must be deducted the weight of child, placenta, membranes and amniotic fluid, leaving a net gain in the body weight of the mother of 15 to 20 pounds. With regard to the energy requirements of pregnancy, there is no great energy demand because, although the basal metabolism of the fœtus is very high per unit of weight, its smallness precludes any great increase in the basal metabolic activity of the mother. It has been stated that the basal metabolic rate in the latter half of pregnancy may be raised 10 to 15 per cent. During lactation the matter is entirely different, for according to most tables of dietary allowances, there should be a daily increase in intake of 600 Calories. This is regarded as sufficient to supply enough energy for the average yields of milk which, in a successful lactation, rises from about half a litre (0 88 pint) per day in the first month to one litre in the fifth month (Garry, 1946). This daily requirement is justified by the fact that one litre of human milk has an energy value of approximately 670 Calories.

ENERGY REQUIREMENTS AND CALORIE INTAKE

Many tables of recommended Calorie intakes have been published in the past, the most important of which have been those of the League of Nations Technical Commission (1936) and the National Research Council (1945–1948). From the data in these tables one would assume that the calorific requirements of the average man of 70 kilograms (154 lb.) is not less than *3000 Calories daily. From numerous dietary investigations,* however, it would appear that these recommended Calorie intakes are perhaps too high, and this is indicated by the fact that the National Research Council state that " the proper Calorie allowance is that which over an extended period will maintain body weight or growth at the level most conducive to well-being " and " it is suggested that the recommended Calorie allowances be regarded as subject to modification of $\pm$ 15 to 20 per cent according to conditions ". As a result of many surveys, certain investigators have reported deficiencies in Calorie intake, because they have taken as the standard the 3000 Calories required by a man weighing 70 kilograms. When, however, the weight of the individual surveyed has been taken into consideration, it has been found that in certain communities *the average weight has been much lower, namely, about 60 kg.* It is doubtless true that most of mankind has always suffered from a shortage of Calories, but many people in the more favoured nations do not so suffer, and it would seem more appropriate, as Keys says, " to concentrate on the *right* amount of Calories instead of insisting that the only problem is to provide more ". " The expansionist philosophy must be curbed in the actual intake of Calories, where the problem of moderation is paramount whenever food is abundant. The experiences of World War II have emphasized not only the tragedy of famine but also the virtues, in some cases, of a less liberal provision of Calories. The lack of health damage, or even the benefit, resulting from recent moderate Calorie reductions in adults in England has been much publicized, but perhaps the analysis for the war years in Switzerland is even clearer. It is difficult to deny Fleisch's conclusion that the [illegible], at least.

'enough

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CHAPTER VII

PROTEIN REQUIREMENTS OF THE BODY

Proteins are amongst the most complex of biological materials forming part of the body and the foods we eat; they have the function of building up new tissue in the growing animal and of repairing the wear and tear of tissue in both the young and adult animal. For this purpose the proteins of animal foods are better than those in foods of plant origin. The best proteins are obtained from milk, eggs and glandular tissues (kidney, liver, pancreas, etc.), since these foods contain the proteins best adapted for the purpose of supporting mammalian life. They are present in all living tissues, and so intimately are they bound up with the structure of the body that it is difficult to find examples of a pure protein existing separately. The best example of a protein is egg-white; this is a pure protein in solution in water. Egg-yolk is a mixture of proteins with fat and salts, just as are cheese and meats. The proteins are made up of numerous nitrogenous compounds or amino-acid units; in the constitution of a protein some 12 to 18 amino-acids are bound together. In the process of digestion these amino-acids are broken from their linkages one with another and are separately taken up by the blood stream and carried to the tissues of the body, where a selection of them is made for *building up various types of proteins which constitute the* tissue. Different tissues require different amino-acids, for example, skeletal muscle selects different amino-acids from those which would be selected by the liver for its growth or repair. The building or repair of the body is something like the building of a city. In the construction of a cathedral or a college, stones of different shapes and sizes are required; in building bungalows or houses, different types again come into use. The building stones used are determined by the design and that is again determined by the use to which the complete building is to be put. So is it with the tissues and organs of the body; their function determines the type of building stones or amino-acids which must be selected from the blood. Such a diverse selection as that which is characteristic of the human body

demands a rich supply of all possible amino-acids. Every protein in the body is continually renewing its structure, constantly selecting the appropriate amino-acids from the large supply presented to it by the blood. But no single protein in our food contains all the necessary amino-acids; numerous proteins must therefore be present in the diet. The most important element in the amino-acids is nitrogen; the others are carbon, hydrogen, oxygen and sulphur. Fortunately we find that the individual proteins contain, not merely one amino-acid, but several different amino-acids, and also many of each. About fifty proteins have been chemically examined and it has been found that they contain usually twelve to eighteen amino-acids, all of which, however, need not be supplied by food

An important point with regard to growth is that the body has the power to synthesize or build up from simple combinations of carbon, hydrogen, oxygen and nitrogen, certain of the required amino-acids the presence of which in the diet is therefore not essential. Those amino-acids which cannot be built up must be supplied by the protein of the food and are therefore called essential or indispensable Some proteins in our foodstuffs do not contain all these essential amino-acids and are known as incomplete or deficient proteins. Proteins containing all the essential amino-acids which have to be supplied by the food for growth and repair are called first-class or, better, complete proteins. There are ten of these indispensable amino-acids, namely, arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. A good example of the need for tryptophan and lysine is seen in the lack of growth in young rats fed on an otherwise adequate diet in which the only source of protein is the zein of maize, which is totally deficient in both tryptophan and lysine. Animals fed on this diet not only cease to grow but steadily lose weight; when tryptophan is added to the diet the fall in weight is stopped, but when both tryptophan and lysine are added normal growth is resumed.

A considerable degree of interest has developed around this question of the 'completeness' or as it is called the 'biological value' of the proteins. By the term 'biological value' is meant the ability of any protein, such as that in meat, milk, eggs, wheat, oats, etc., to provide for the growth of the young animal and the maintenance of the adult. Recent work on

this subject has shown that the biological value of the mixed proteins in normal dietaries is surpassed only by that of the proteins of eggs and milk. Proteins of maize and wheat are well balanced with respect to their essential amino-acids and compare favourably with the proteins of animal origin. This indicates that the process of amino-acid supplementation which takes place in a normal diet is effective in compensating for the varying deficiencies of the individual proteins composing it. The incomplete proteins play a part in enhancing the nutritive value of proteins of a higher biological value than they themselves possess. The nutritive value of individual proteins depends on three factors; (1) the amount, (2) the digestibility and (3) the biological value of the protein. Consider these three points briefly:—

(1) No protein unless in adequate supply will produce its *full nutritive effect.*

(2) Digestibility is associated with the form in which the protein exists in food as eaten and the extent to which it is broken up by the enzymes or ferments in the alimentary canal. In general terms, proteins of animal origin are more easily digested than those of vegetable origin, with one exception, *the protein of uncooked egg-white.* If one takes the coefficient of digestibility of milk and meat protein as 98 (i.e. for every *100 grams of protein nitrogen consumed 98 would be utilized),* that of cereals and legumes would be 90 and 70 respectively. *The low figure for the proteins of cereals and vegetables is due* to the presence in such food of large quantities of indigestible *cellulose which protects the protein from enzyme action.* When proteins, isolated from the structural elements of cereals and vegetables, are tested they have a digestibility coefficient not far removed from that of meat or milk.

(3) The biological value of a protein depends upon the amino-acids of which it is composed. Some proteins have *amino-acids which will fully make good wear and tear* and also support growth; these are the complete proteins; others are very good for maintenance but will not support growth, these are partially incomplete; others again can support neither maintenance nor growth, these are the incomplete proteins.

The proteins of highest biological value, that is, the complete proteins, are found in eggs, milk, cheese, meats and nuts.

In vegetable and cereal foods an incomplete protein is often associated with a complete protein, and in some vegetables the protein may be wholly incomplete. Table 25 shows the nature of the protein in certain foods.

TABLE 25

Food	Complete Proteins	Incomplete Proteins
Meat	Albumin and myosin	—
Milk	Caseinogen and lactalbumin	—
Eggs	Ovalbumin and ovovitellin	—
Wheat	Gliadin	Glutenin
Gelatin	—	Gelatin
Soya bean	Glycinin	Legumin
Barley	—	Hordein (partially)
Maize	Glutelin	Zein
Almonds and nuts	Excelsin	—
Peas	—	Legumin

The further development of this subject demands a knowledge of the various amino-acids in these proteins. The complete proteins containing all the key amino-acids, which the body cannot build up from simpler compounds, must be present in the daily diet. While cereals and vegetables have incomplete proteins, i.e. proteins lacking some of the 'essential' or indispensable amino-acids, it must not be thought that these incomplete proteins are of little value. It has been shown that neither the gliadin nor the glutenin of wheat has by itself a high food value, but together their food value is greatly enhanced, since the lysine-rich glutenin has a strong supplementary action on the lysine-poor gliadin. Most important in this respect is the fact that small amounts of complete protein have a strong supplementary effect on incomplete proteins. For example, a piglet fed on corn does not grow well because the complete protein, glutelin, has no great supplementing action on the incomplete protein, zein. But if to the diet of corn a small amount of milk be added, giving the complete proteins caseinogen and lactalbumin, the rate of growth is almost fully restored. This is but one example from many which emphasize the importance of a good mixed diet, e.g. cereals and milk; meat and vegetables; cold meat with a mixed salad of greens, eggs, tomatoes and mayonnaise.

The Protein Requirements of the Body.—Protein, which is required for energy and body building, is an essential part of every cell in the body. It is present in large amounts in *apparently inactive tissues such as bone.* Muscle consists of 75 per cent water and 25 per cent of solid material, and of this solid material 80 per cent is protein, the remaining 20 per cent is made up of extractives and inorganic salts.

The question arises, "How much protein is required for body building, how much for energy?" The child requires protein for growth; as much as one-third of the total intake of protein may be used for growth. The adult requires but little for repair. It is important to remember that muscular work does not entail any appreciable breakdown of body protein. Work determines energy needs, but such energy needs are supplied by carbohydrates. Muscular work is not done primarily at the expense of protein, but long continued work does produce an increase in the breakdown of muscle protein, which being formed into glucose makes good any reduced carbohydrate supply of the body. And here it might be mentioned that mental work also does not appreciably increase the energy needs of the body. The body does not store protein in the manner in which it can store carbohydrate or fat, but a rich protein meal will lead to a very temporary storage of amino-acids or protein in the liver; and increased or prolonged exercise will produce a greater development of muscle tissue. It can therefore be accepted that all nitrogenous material in excess of that immediately required is excreted by the kidney. To have the excretory organs burdened with the excess of the products of protein breakdown is a disadvantage. Those amino-acids of the protein which are used for the building of tissue have their nitrogen built into the body structure, while all those which are in excess have their nitrogen removed by conversion into new nitrogen-containing substances which must be excreted, e.g. urea; the remainder, i.e. the non-nitrogenous part—carbon, hydrogen and oxygen—must be burned and is got rid of as CO_2 and water.

Recommended Allowances for Protein and Calories.—A man weighing 70 kilograms or 154 lb. generally requires about 70 grams of protein per day. The figure varies according to age, sex, occupation and race (see Table 26); for example, in this country and in the United States of America, those who

take rich protein food may ingest from 80 to 120 grams of protein per day. An Esquimo who lives on meat may take 300 grams; a vegetarian in the tropics, e g a Hindu, may take not more than 50 grams per day. Curiously enough the former lives on a plentiful supply of animal protein while the latter exists on a meagre supply of protein of rather poor quality. It

TABLE 26

COMPARISON OF AMERICAN ALLOWANCES OF CALORIES AND PROTEIN (N R C. STANDARDS) WITH VALUES REVISED TO SUIT DIETARY HABITS IN THE UNITED KINGDOM[1]

	American Allowances			Revised (Net Values)		
	Calories	Protein g	Percentage of Calories derived from Protein	Calories	Protein g	Percentage of Calories derived from Protein
	70 kg			61 kg		
Man						
Moderately active	3000	70	9 6	2900	75	10 6
Very active	4500	70	6 4	4200	110	10 7
Sedentary	2400	70	11 5	2400	65	11 1
Woman (56 kg)						
Moderately active	2400	60	9 8	2500	65	10 7
Very active	3000	60	8 2	3200	80	10 3
Sedentary	2000	60	11 7	2100	55	10 7
Pregnancy (latter half)	2400	85	13 9	2500	75	12 3
Lactation	3000	100	13 7	3000	05	13 0
Children up to 12 years						
1 to 3 years	1200	40	13 7	1200	40	13 7
4 to 6 years	1600	50	12 8	1600	50	12 8
7 to 9 years	2000	60	12 3	2000	65	13 3
10 to 12 years	2500	70	11 5	2500	80	13 1
Children over 12 years						
Girls 13–15 years	2600	80	11 7	2800	90	13 2
Girls 16–20 years	2400	75	12 8	2400	70	12 0
Boys 13–15 years	3200	85	10 9	3200	100	12 8
Boys 16–20 years	3800	100	10 8	3800	110	11 9

[1] *After* D P. Cuthbertson (1944), *Brit. Med Bull*, 2, 207 and National Research Council, U S.A., 1948

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The question arises, "How much protein is required for body building, how much for energy?" The child requires *protein for growth; as much as one-third of the total intake* of protein may be used for growth. The adult requires but little for repair. It is important to remember that muscular work does not entail any appreciable breakdown of body protein. Work determines energy needs, but such energy needs are supplied by carbohydrates. Muscular work is not done primarily at the expense of protein, but long continued work does produce an increase in the breakdown of muscle protein, which being formed into glucose makes good any reduced carbohydrate supply of the body. And here it might be mentioned that mental work also does not appreciably increase the energy needs of the body. The body does not store protein in the manner in which it can store carbohydrate or fat, but a rich protein meal will lead to a very temporary storage of amino-acids or protein in the liver; and increased or prolonged exercise will produce a greater development of muscle tissue. It can therefore be accepted that all nitrogenous material in excess of that immediately required is excreted by the kidney. To have the excretory organs burdened with the excess of the products of protein breakdown is a disadvantage. Those amino-acids of the protein which are used for the building of tissue have their nitrogen built into the body structure, while all those which are in excess have their nitrogen removed by conversion into new nitrogen-containing substances which must be excreted, e.g. urea; the remainder, i.e. the non-nitrogenous part—carbon, hydrogen and oxygen—must be burned and is got rid of as CO_2 and water.

Recommended Allowances for Protein and Calories.—A man weighing 70 kilograms or 154 lb. generally requires about 70 grams of protein per day. The figure varies according to age, sex, occupation and race (see Table 26); for example, in this country and in the United States of America, those who

(1) A child, aged 8 years.
Weight = 54 lb. = 24 kilograms.
Energy requirement = 2000 Calories.
13 per cent of 2000 = 260 Calories = 62 grams protein.
Protein requirement by weight = 2.6 × 24 = 62 grams protein.

(2) An adolescent boy, aged 16 years.
Weight = 122 lb = 55 kilograms.
Energy requirement = 3500 Calories.
12 per cent of 3500 = 420 Calories = 100 grams protein.
Protein requirement by weight = 1.8 × 55 = 99 grams protein.

(3) An adult, moderately active, aged 25 years
Weight = 143 lb = 65 kilograms.
Energy requirement = 3000 Calories.
10 per cent of 3000 = 300 Calories = 71 grams protein.
Protein requirement by weight = 1.1 × 65 = 71 grams protein.

A study of tabular data in this manner impresses upon one the great need of the growing body for protein. A little further calculation will show that a child of 1 year weighing 20 lb. requires 36 grams of protein, and all of it must be animal protein. It may be safely affirmed that from 5 to 15 years of age the human body should have half of its total protein in the form of animal protein, the remainder being obtained from cereal and vegetable sources. This does not necessarily imply that animal protein is indispensable, it does imply that for the growth and development of children and adolescents animal protein is the best source of the essential or indispensable amino-acids. Upon the same reasoning is based the statement that expectant mothers should receive 85 grams of protein and nursing mothers 100 grams of protein daily, of which, in both cases, half should be animal protein.

Table 26, which links up Calories with protein allowances should be consulted for details concerning age groups.

We see, therefore, that we begin life with a very high protein requirement in terms of body weight, namely, about 4 grams per kilogram of body weight, that this falls steadily throughout adolescence and that, adolescence safely passed, no

has been shown experimentally that not less than 30 grams of protein must be assimilated to make good the wear and tear of the body. Any protein in excess of this figure will be used for the production of energy. The extent to which protein is burned for fuel depends upon the degree to which the body utilizes carbohydrate and fat for energy. If in the adult there is an adequate supply of carbohydrate for energy, protein need never be used specially for this purpose. The protein intake, in diets liberal in energy-producing carbohydrates and fats, should always be in excess of the minimum requirements of the body for growth and repair. Much scientific controversy has been waged over the *minimum intake of protein necessary* for healthful living. Chittenden in Boston maintained that men could live well on a protein intake of 44 grams per day. This has been criticized by German and English workers, who have shown that a minimum protein diet ultimately results in a lack of robustness or vitality and a predisposition to infectious diseases. In experiments on rats—and standard rats give results which are of great value in leading to conclusions which are of importance for man—it has been found that minimal protein diets continued over three or more generations lead to very definite deficiencies. It may be that the second generation reveals nothing that could be interpreted as abnormal, but the third generation invariably shows changes in size, rate of growth, number of litters and, what is noteworthy, in the number of deaths in the litters. When dogmatic criticisms are levelled *at scientific findings, it is well to ask if such criticisms are based* on results covering three or four generations.

For children and adolescents it may be maintained that about 12 to 14 per cent of the total Calories should be furnished by protein, while for adults 10 to 11 per cent is regarded as sufficient. If we consider the Calorie and protein requirements of children, adolescents and adults (Table 26) in relation to age and weight we shall find that these percentages are substantially correct. Take three examples, with 3000 Calories as the unit of energy requirement, and the protein requirements in terms of grams per kilogram of body weight at various ages, which are:

Age: years	1	5	8	11	14	16	18	25
Protein: g./kg.	4·0	3·0	2·6	2·4	2·1	1·8	1·6	1·1

On the other hand, while retaining the same protein and calorific values of the diet, the latter by adding fat, all carbohydrate be withdrawn, then the nitrogen output will increase, indicating a greater oxidation of protein. Whenever the carbohydrate is restored, the degree of breakdown of protein returns to normal. Physiologically adequate amounts of carbohydrate thus spare protein, not only by serving as fuel so that the protein is not called upon for energy, but also by forming combinations with the products of protein breakdown from which amino-acids may be formed. From the results of many bio-chemical experiments it has become increasingly clear that carbohydrate plays a very important part in protein metabolism. Cuthbertson and Munro have demonstrated that excess of carbohydrate (280 Calories) or fat (700 Calories), in a diet containing 70 grams of protein and supplying 3200 Calories, caused a great increase in body weight in man. In a word, the body can only grow to its optimum in size and strength if, in the presence of an adequate amount of protein, it receives its optimal supplies of carbohydrate and fat.

The question, "How much protein should be taken?" has been answered. It naturally leads to a second question, namely, "How can we secure the correct proportion of protein in our diet?"

The answer lies in a knowledge of the protein rich foods, which are eggs, meat, cheese, milk, legumes and nuts.

The next question which arises is how to secure, for example, the 35 grams of animal protein for a child of 7 or 8 years of age? This can be done by selecting appropriate amounts of animal foods as shown :—

Foodstuff	Amount	Protein (grams)	Calories
Milk . .	1¼ pints	29	510
Egg or . . .	1	6	78
Meat .	2 oz	10	135

This gives 35 grams of animal protein and over 600 Calories per day. A further 35 grams of protein can be secured by eating grains and vegetables, thus giving the optimum According to Sherman, "given a full quart of milk in the daily dietary of the growing child, the other foods may be selected

one, unless very actively engaged in manual work, need ingest *more than* 1 *gram* of protein per *kilogram* of body weight, or 0·5 gram or $\frac{1}{60}$ oz. per lb. of body weight. We realize something of the biological value of protein as building material when we compare the protein content of the milk of the mother with the rate of growth of the newborn progeny. Note how rapidly a kitten, a lamb, a piglet, or a calf doubles its birth weight compared with the time taken by a human baby. Note also the amount of protein in the milk of the cat, the ewe, the *sow, the cow and the human mother.*

The kitten doubles its weight in	7 days ;	Protein of milk	= 9 5 g. %
The lamb	,,	,,	10 days ;	,, ,,	= 6 3 g. %
The piglet	,,	,,	3 weeks ;	,, ,,	= 5 2 g %
The calf	,,	,,	7 weeks ;	,, ,,	= 3 5 g %
The baby	,,	,,	6 months ;	,, ,,	= 1 3 g %

While a baby thrives on cow's milk, the calf would fade away on human mother's milk, and the lamb on a similar diet may succeed in standing on its feet before it died, which event would probably take place in about one week.

The reason for the presence of protein in the diet is to provide nitrogen, sulphur and phosphorus in the form of amino-acids for growth, maintenance, reproduction and lactation.

The Sparing Action of Carbohydrate and Fat on Protein.—It has long been known that carbohydrate has a sparing action on protein metabolism. Several investigators have shown that if a man be starved, the output of nitrogen in the urine falls. This indicates that, after the first two days of inanition, when carbohydrate stores have been rapidly diminished, the body obtains energy from protein and fat. When, as in the last stage of severe or prolonged starvation, almost all fat has disappeared, the body has to rely on its protein for the *supply of energy. The loss of protein can, however, be stopped* if carbohydrate be administered in amounts sufficient to meet the energy requirements of the resting man, i.e. about 35 Calories per kilogram. Whenever the protein wastage stops, the tissues will be restored by a rebuilding of the protein part of their structure. This is the extreme case and here only carbohydrate, as glucose, is effective. If the diet be sufficient in protein and the body is in nitrogen balance, the addition of carbohydrate to the food will conserve the protein, as is always indicated by a diminution of nitrogen excreted in the urine.

On the other hand, while retaining the same protein and calorific values of the diet, the latter by adding fat, all carbohydrate be withdrawn, then the nitrogen output will increase, indicating a greater oxidation of protein. Whenever the carbohydrate is restored, the degree of breakdown of protein returns to normal. Physiologically adequate amounts of carbohydrate thus spare protein, not only by serving as fuel so that the protein is not called upon for energy, but also by forming combinations with the products of protein breakdown from which amino-acids may be formed. From the results of many bio-chemical experiments it has become increasingly clear that carbohydrate plays a very important part in protein metabolism. Cuthbertson and Munro have demonstrated that excess of carbohydrate (280 Calories) or fat (700 Calories), in a diet containing 70 grams of protein and supplying 3200 Calories, caused a great increase in body weight in man. In a word, the body can only grow to its optimum in size and strength if, in the presence of an adequate amount of protein, it receives its optimal supplies of carbohydrate and fat.

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The next question which arises is how to secure, for example, the 35 grams of animal protein for a child of 7 or 8 years of age? This can be done by selecting appropriate amounts of animal foods as shown :—

Foodstuff	Amount	Protein (grams)	Calories
Milk . . .	1½ pints	29	540
Egg or . . .	1	6	78
Meat . . .	2 oz.	10	135

This gives 35 grams of animal protein and over 600 Calories per day. A further 35 grams of protein can be secured by eating grains and vegetables, thus giving the optimum. According to Sherman, "given a full quart of milk in the daily dietary of the growing child, the other foods may be selected

chiefly with reference to qualities other than their protein content. Without a liberal use of milk, the proper feeding of the growing child becomes a very difficult problem." Eggs, cereals, with a little meat occasionally, will raise the total protein in the diet of a child to about 15 per cent of the total Calories if the quart of milk is adhered to. It is not necessary as some erroneously think that the child should drink the quart of milk. It should appear in any form in the daily dietary.

TABLE 27

THE PROTEIN CONTENT OF COMMON FOODSTUFFS

	Grams per 100 grams		Grams per 100 grams
Cheese	25–37	Haddock	16
Egg, raw	12	Herring	16
„ white	9	Lemon sole	16
„ yolk	16	Whiting	16
Milk, whole	3·3	Salmon	17
„ dried	26		
„ condensed	7	Almonds	20
„ „ skimmed	9	Peanuts	28
		Beans, butter	19
		„ haricot	21
Bacon, Wilts	14	Lentils	24
Beefsteak	19		
Ham	15	Chocolate, milk	7
Liver	17	„ plain	5
Mutton	18		
Bovril	29	Cocoa powder	20

The energy and protein requirements of pregnancy and lactation are as stated in Table 26. Dietary surveys carried out recently by the sub-committee on Nutrition of the Department of Health for Scotland have shown how serious has been the deficit in animal protein in the diets of nursing mothers (Cruickshank, 1947). Priority supplies of milk have been of great value, but to secure at least 40 grams of animal protein every nursing mother should have 2 pints of milk and one fresh egg or its equivalent per day.

There has been some exaggeration of the ill-effects of taking moderately liberal amounts of protein and a confusion of these with the effects of eating too much meat. Intestinal putrefaction does not necessarily accompany the daily ingestion of 100–120 grams of protein. Intestinal hygiene can be maintained with milk, eggs, cheese, grains, vegetables and moderate amounts of meat.

A liberal protein consumption with a moderate amount of meat is better than a restricted protein intake or a poor protein intake such as is obtained with a vegetarian diet.

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CHAPTER VIII

FOODSTUFFS AND THEIR FUEL VALUE

CARBOHYDRATES, FATS AND PROTEINS

The Source of Energy.—In physics, energy is defined as the ability to do work; in biology, energy may be regarded as a force which manifests itself in various ways, as work, heat, light or sound. The energy or fuel value of foods is always stated in Calories, a Calorie being the heat unit. Units of heat and mechanical work are mutually convertible and it is therefore possible to transform Calories into units of work (foot-pounds or gm.-cm.): this, however, is not done in dealing with foods. In the utilization of food, heat is produced and work is done; if the energy intake is in excess of the needs of the body, it is stored as carbohydrate and fat. The sun is the source of all energy in the form of light and heat, and man can become a partaker of solar energy through the medium of the food he eats. In virtue of chlorophyll, the green pigment which they contain, plants store energy in the form of various chemical compounds such as carbohydrates and fats which are made up of carbon dioxide from the air and water from the soil. Plants are also able to synthesize or build up proteins from *simple inorganic nitrogenous substances*, or in some cases, by making use of atmospheric nitrogen. This remarkable achievement is something of which the animal body is incapable, and, therefore, to secure his protein man must depend upon a preformed supply in his diet. The body can build up proteins if given rather *complex organic* nitrogenous substances which are formed in the alimentary canal as the result of the digestion of preformed animal or vegetable protein.

The Fuel or Energy Value of Carbohydrates, Fats and Proteins.—The energy value of carbohydrate is 4·1 Calories per gram; this is an average figure because the term carbohydrate covers glucose, cane sugar and starch, the energy values of which are 3 35, 3 95 and 4 23 Calories per gram respectively. For fats, the energy value as determined by total combustion of a fat in the calorimeter is 9 45 Calories per gram, for protein,

5 6 Calories per gram; but, in calculating the fuel value of fat and protein, allowance must be made for the heat lost during digestion—approximately 1 per cent in the case of fat and 5 per cent in the case of protein. While carbohydrate and fat are oxidized to carbon dioxide and water, protein is oxidized in the bomb calorimeter to carbon dioxide, water and nitrogen When burned in the body, protein yields no free nitrogen; the nitrogen is eliminated as organic nitrogenous compounds—urea, uric acid, creatine, etc.—in the urine, and the amount of heat lost is about 1·17 Calories per gram of protein digested. Heat is lost by the elimination of nitrogen in the fæces, and heat is required for the solution of proteins and urea; this further increases the heat loss by 0 23 Calories per gram of protein digested. The total heat thus lost is 1·4 Calories and must be subtracted from the original figure, 5 6, leaving 4·2 Calories as the physiological heat value of one gram of protein. Thus the following final figures for the calculation of the fuel values of the three proximate principles of our food, in Calories per gram, are:—

Carbohydrate 4 1, Fat 9 35; Protein 4 2

Knowing the composition of any food in terms of protein, fat and carbohydrate, its fuel value can be determined; for example, 100 grams or 3·57 oz. of milk gives

Protein	3 3 grams × 4 2 =	13 86 Calories
Fat . . .	3 6 grams × 9 35 =	33 66 "
Carbohydrate .	4·4 grams × 4 1 =	18 00 "
		65 52

Tables of food values have been drawn up in many countries and are repeatedly under revision. In this country the latest figures dealing with the energy and nutritive values of war-time foods have been issued by the Medical Research Council, in War Memorandum No. 14, 1945 (reprinted 1950).

When energy and nutritive requirements are set out in Tables, the figures relate to physiological needs as satisfied by uncooked food. This implies a knowledge of waste in the cooking of various foodstuffs, and therefore when cooked, canned or preserved foods are used, appropriate Tables must be consulted; allowance is made for this in many of the more recently issued Tables.

Sugars and Starchy Foods.—To most people sugar is that sweet granular foodstuff which appears on the table; this is cane sugar and is made from the sap of the sugar-cane. Cane sugar, or sucrose, is present in the juices of sugar-cane, beetroot and sugar maple. Sucrose is composed of equal parts of glucose and fructose. These three sugars, glucose, sucrose and fructose, are most commonly found in the sap of many plants and in the juice of fruits, for example, fructose is found mixed with glucose in honey and in fruit sugar. Besides these there are other two sugars of importance, namely maltose or malt sugar and lactose or milk sugar. Molasses, much used on the American continent, is the concentrated liquor left after the impure brown sugar crystals have been removed in the process of making pure cane sugar, and contains a good proportion of calcium and iron along with the sugar. This can be further refined to form black treacle, from which, by the further removal of impurities, golden syrup and ultimately cane sugar are produced. Starch is found in seeds, tubers and roots of plants and wherever found, is chemically the same It is present in the plant, in envelopes of cellulose, in the form of grains or granules; each plant has a characteristic form of

TABLE 28

THE SUGAR CONTENT OF COMMON FOODSTUFFS

	Per cent		Per cent
Granulated sugar	100	Sultanas (dried)	65
Brown sugar	98	Dates (dried)	64
Maple sugar	83	Raisins (dried)	64
Syrup (golden)	79	Currants (dried)	63
Honey	77	Condensed milk (sweetened)	56
Marmalade	70	Chocolate	55
Treacle (black)	67	Figs (dried)	53

THE STARCH CONTENT OF COMMON FOODSTUFFS

Tapioca	95	Rye	80
Sago	94	Ryvita	79
Cornflour	92	Semolina	77
Arrowroot	90	Macaroni	77
Rice (polished and raw)	87	Oatmeal (raw)	73
Maize	85	Toast (average)	64
Barley	81	Bread (white)	53
Flour (white)	76	Lentils (raw)	51
,, (wholemeal)	67		

granule, so that one can readily distinguish wheat starch from potato starch when the grains or granules are examined under a microscope. Starch is present in unripe fruits, the banana is an example, for, in the form in which it is generally eaten it is not completely ripe; as it ripens, the starch is converted into fructose or fruit sugar.

Cooking ruptures the granules, changes the starch chemically, makes it more soluble and therefore more easily digested. All these sugars and starches are classed under the term carbohydrate, a name given because of the elements carbon, hydrogen and oxygen, which alone make up these substances. Practically all the carbohydrates used for food come from the vegetable kingdom. The sugar found in the blood is glucose; it is stored in the liver and muscles as glycogen, which is a combination of glucose molecules and is sometimes called animal starch. Milk sugar, a carbohydrate of animal origin, is found in milk and is the only sugar of animal origin. When the term "carbohydrate foodstuff" therefore is used, it does not necessarily imply that only sugar is to be found in the food referred to. Many carbohydrate foods, e.g. wheat, milled rice, which are almost pure starch, contain 9 to 11 per cent protein; but certain vegetables, e.g. dried beans and peas, have 60 per cent starch and 20 per cent protein. Potatoes, regarded as a very starchy food, contain about 18 per cent of starch, 2 per cent of protein and 78 per cent of water. Potatoes and milk although they have a high water content (milk 87 per cent water), are nevertheless very valuable foods because they are consumed in comparatively large quantities.

Foods are always grouped according to their richest constituent.

FACTS ABOUT CARBOHYDRATE AND FAT RICH FOODS

Grains.—The cereal grains have formed the chief sources of food supply for all people since agriculture began. They are easily cultivated, can be stored for long periods, are palatable and economical. Of the cereal grains, wheat, rye, barley and oats have formed the main food supply of the peoples of Europe and America for many centuries, while rice has been the staple diet of the Chinese and Japanese from time immemorial. While

it is a commonplace to say that "bread is the staff of life", it is astonishing, to all who look into the figures for bread consumption in our industrial areas, to realize the extent to which the working classes cling to this staff of life, even to the exclusion of equally nourishing foods. Many are indeed incredulous when informed that thousands of men and women eat no less than 7 lb. of bread per head per week. It may be said that the amount of bread eaten is an indication of the standard of living of the great mass of working people in this country. Wheat and other grains are, however, coming into much greater use in this country than was the case some 20 or 25 years ago. The cultivation of wheat has developed tremendously. This is due in a large measure to scientific research, whereby many grains, especially wheat, have been adapted to dry regions and more northerly climates. In Canada the Red Fife wheat, which originated from a single grain of Galician wheat included in a sample sent to a farmer, David Fife, from Danzig in 1847, held the field until superseded by the Marquis, which had a shorter growing period and could therefore be cultivated farther north. In this way, by developing seeds which will mature more quickly, the wheat belt has been extended northwards. In the United States drought-resisting strains were introduced from South Russia. Australia has developed wheats which can ripen on lands which receive only 15 inches of rain annually. The story could be extended to India and Egypt where British engineering feats, coupled with agricultural research, have greatly added to the wheat production of the world. Barley and rye are grown where wheat does not thrive, e.g. in parts of Germany, Denmark and the United States of America. Oats, while of no value for breadmaking, have in the form of porridge and oat cakes "general nutritive qualities greater than those of any other cereal" (Bogert). To prepare the grain for human consumption it must be milled. Milling removes the husk, the outer coats or bran and the germ, which must be removed if the flour is to be stored for any length of time without deterioration. A too complete milling removes fat, vitamins and salts with the germ and protein, vitamins and salts with the outer layers (see Fig. 21). All the protein and salts are, however, not removed, as some are present in the endosperm or kernel. Rice that has been highly milled and polished is an example of the worst that can befall any grain,

for by these processes the germ, bran and outer coats are all removed. The tremendous loss in salts is accompanied by a complete loss of vitamins. By parboiling the rice—treating the unhulled rice with hot water (80° C.) and steam—two important changes are effected; the distribution of vitamin B_1 and nicotinic acid is changed and the scutellum portion of the germ appears to remain in the grain after milling. (Hinton, 1948, Done, 1949) Heavy milling removes the germ and with it most of the vitamin, parboiling saves some, but not a great

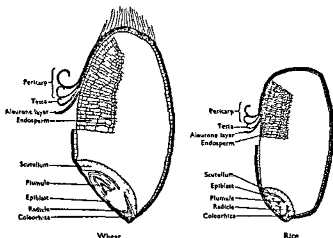


FIG 21 —Comparative diagram of the structure of the wheat grain and of the rice grain (*Dr. J J C Hinton, Cereals Research Station, St Albans*) (*By courtesy of British Journal of Nutrition*)

deal, by transferring vitamin to the endosperm and by gelatinizing the endosperm immediately beneath the germ thus retaining the scutellum which contains about 50 per cent of the vitamin B_1 content of the whole grain. As to how much scutellum will be left after heavy milling is another question. Dr. Hinton has suggested a study of the effects of mild soaking in hot water followed by light milling as an alternative to a boiling or steaming treatment followed by heavier milling, since he has found that soaking improves the adhesion of the germ without seriously reducing its vitamin B_1 content. White flour represents a degree of milling in which the outer coats have been removed; there is no great loss of protein, but, the germ

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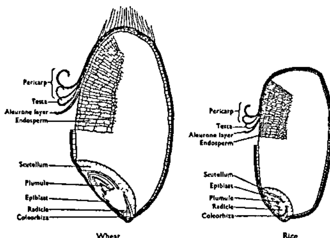


FIG 21 —Comparative diagram of the structure of the wheat grain and of the rice grain (*Dr J. J C Hinton, Cereals Research Station, St Albans*) (*By courtesy of British Journal of Nutrition*)

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having been removed, a considerable loss of vitamins of the B group has occurred. The whole flour is the ideal form in which the grain should be used, as then there is no loss of proteins, vitamins or mineral salts. Further reference will be made to this subject when dealing with bread.

Sugar.—This is a most highly refined and concentrated food. Three hundred years ago sugar was unknown as an article of diet. In the days of Marie Antoinette it was an expensive luxury sold at about 4s. or 5s. per lb. At the end of the Napoleonic wars, which had cut Europe off from her source of sugar supplies, France and Germany had established the manufacture of sugar from beet, but English people had insular prejudices concerning beet sugar and were apparently content to pay dearly for cane sugar which was rapidly becoming a necessity. The history of sugar is the history of a *habit-forming foodstuff. We are all aware of the naïve way in* which many persons satisfy their craving for sugar. The manufacturers of sugared sweets need no slogan. Like alcohol, tobacco, morphine and cocaine, sugar has its addicts, and they are not all in the United States and Canada; as sugar consumers we run a very close second to the people of the North American continent; the war reduced our intake markedly, to the distinct advantage of not a few. From 1836 to 1936 the consumption of sugar increased from approximately 10 to 100 lb. per head per annum. The great increase in the use of sugar has not been without its effect upon our taste for other and better foods. The craving for sugar has led to the use of unbalanced diets, for sugar, in excess, destroys the appetite for those foods which supply the all-essential proteins, vitamins and mineral salts. It does this because a concentrated sugar solution is hygroscopic. Here, then, is the cause of the irritation of the mucous membranes of the stomach and intestines *which follows a too great indulgence in sugar. The greatest* danger, physiologically, lies in the fact that sugar, which is not a body builder but a source of energy, so quickly satisfies the appetite that it abolishes the desire for other foods. The importance of this fact to the growing child is at once evident. Body building and energy are the two vital needs of the child. It is not unfortunate that energy requirements can *be so readily* supplied by those things for which the child craves; but it is unfortunate that the body-building foods cannot be so easily

nor so cheaply supplied. No child should be allowed to come to a meal with an appetite cloyed by a too free indulgence in sweets or candy. Sweets should always be given at the end of a meal and it is for this reason that the best forms of dessert are those fruits which contain small amounts of sugar

In the adult, the continued excessive consumption of sugar may lead to a weakening of the pancreatic gland whose function it is, by means of insulin, to control carbohydrate metabolism. A diminution in the production of the hormone, insulin, leads to a failure of the body tissues to burn and to store sugar which is presented to it by the blood. When this happens, blood sugar rises and overflows through the kidneys, giving rise to those signs which are indicative of diabetes. Other untoward results of excessive intake of sugar are liver disorders, arthritic troubles, overweight and all the ills that follow in its train. Many of the vague ills that flesh was heir to before the war could have been dissipated by eating less carbohydrate, either as potatoes, chocolates or highly sweetened desserts. It is an interesting point that starches do not tend to cause so much trouble as the sugars. This is due to the fact that starch is digested gradually, being broken down to dextrin and maltose by the enzyme ptyalin in the saliva, a process which continues

the glucose as it is formed is the reason for starch causing so little digestive disturbance. Excessive use of starch will of course lead to the same ills which are attendant upon an excessive sugar consumption. Foods rich in starch are deficient in vitamins A and C and to a less extent in fats. Where starches form too great a part of an unbalanced diet there do we find bad teeth, poor bone development, anæmia and a diminished resistance to infection. It is for this reason that starches and sugars, valuable and economical sources of energy though they are, must be supplemented by eggs, milk, fruits and vegetables.

Fats.—Fats are found mainly in foods of animal origin. Being unable to store large amounts of carbohydrate, the animal body transforms carbohydrates into fat which is stored in almost every part of the body. Fat thus serves two purposes; it is a reserve of energy and prevents heat loss from the surface of the body. Although the fats are mainly of animal origin a few plants have the power to store fat in considerable amounts

in their fruits and seeds. Examples of plant or vegetable are *olive oil*, cocoanut oil and cotton-seed oil. Nuts are rich in fats. Fruits are generally not well supplied with Vegetable fats such as olive oil, are spoken of as oils becaus ordinary temperatures they are liquid. It is better not to the term, oil, since it is generally applied to mineral oils, wl are not glyceryl esters but hydrocarbons. Animal fats at r temperatures are solid or semi-solid. The melting points of are always higher than their solidification points; for exam tristearin melts at 72° C., but solidifies at 52° C. Fats wl have lower melting-points than the temperature of the b (37·5° C.; 98 4° F.) are digested more easily than those wl remain semi-solid in the alimentary tract. The following the melting points of certain fats:—

Butter fat	28–33° C.
Pork fat	36–46° C.
Beef fat	40–48° C.
Mutton fat	46–50° C.
Human fat	17·5° C.

The fats found in milk, cream and egg-yolk are the m easily digested because they are in the form of an emulsi i.e. the fat is present in very fine droplets which allows digestive juices to surround and attack them. Fats are adap to the animals and plants in which they are found. Pla and cold-blooded animals, e.g. fish, have fats of low melti point so that when we use them they are generally in the fo of oils. Cattle and sheep have fat which is slightly har than that of pigs, the latter being largely herbiverous anim

The most used animal fat is butter, made from the milk the cow, or, as is common in many countries, from the milk the goat or Indian buffalo. Milk and cream are very valua sources of fat; in the former, the percentage of fat varies fr 3 to 4 per cent and should not be less than 3 per cent; in t latter, the fat content varies from 18 to 40 per cent. In eggs, t fat is contained exclusively in the yolk, where it averages 31·7 p cent. In the whole egg as bought, which weighs between and 64 grams or 1¾ to 2¼ oz., the amount of fat is approximat 6 0 grams.

Cheese made from cream contains a large amount of fa certain cheeses are very rich in this respect, containing up

86 per cent of fat. In fish, fat is stored in the liver in the form of oil hence fish livers are the source of very valuable oils, e g cod-liver oil, halibut-liver oil, etc. With the exception of herring, salmon, mackerel and trout there is very little fat in the flesh of fish.

The Value of Fat in the Diet.—Fat has a fuel value more than double that of an equal amount of either protein or carbohydrate. The following foods in the amounts stated are of equal calorific or fuel value: 1·0 oz. of butter, 2·1 oz. of carbohydrate, 2 4 oz of meat, 2 lb of cabbage and 3 lb of lettuce. The high calorific value of fat makes it possible to increase

TABLE 29

THE FAT CONTENT OF COMMON FOODSTUFFS (EDIBLE PORTION)

	Grams per 100 grams		Grams per 100 grams
Olive oil	100	Sardines (in oil)	24
Butter	83	Herring (raw) (Summer)	18
Margarine	85	Salmon	15
Cheese, cheddar	34	Mackerel	8
,, cream	86		
Bacon (average)	38	Almonds	53
Ham (average)	39	Barcelona nuts	65
Mutton and pork	25–45	Brazil nuts	61
		Coconut (dessicated)	62
Lard	99	Chocolate, milk	34
Suet	99	,, plain	32

markedly the fuel value of a diet without any appreciable increase in its bulk. It is usually a very simple matter to reduce the fuel value of a diet. Marked reduction can be made by omitting all definitely fatty foods, reducing the amount of butter and cutting out of the diet all rich salad dressings.

In so far as fats are concerned the vitamin content varies considerably. Vitamin A, while it is contained in butter and egg-yolk, is entirely absent from fats of vegetable origin. It is for this reason that vegetable fats are not substitutes for animal fats; and so it is with butter substitutes, those made from vegetable oils are of no value in this respect unless vitamins A and D have been added in their manufacture. The two fat soluble vitamins, A and D, are to be found in the livers of all fish and also in the flesh of fatty fish. Liver is the source from which the well known highly concentrated preparations of

these vitamins now on the market are manufactured. It is amazing how greatly people vary in their ability to digest and assimilate fat. Fat tends to delay digestion, which explains why a meal with fat gives a sense of satiety. In any form, fat, while prolonging digestion, adds considerably to the fuel value of the meal.

Dietary rules for the use of fatty foods are quite simple, for most people are aware of the disadvantages of a too fatty meal. For young children and those who suffer from gastric and intestinal disorders, diseases of the liver and acute fevers, fried foods, fat meats and pastries should be excluded from the diet. The most easily digested forms of fat are those in which the fat is well emulsified, namely milk and eggs. Butter is usually well digested by most, this is due to its low melting-point. Ice cream is a very good form in which to add fat to a diet. Cheese also is an excellent source of fat as it is of protein. It is self-evident that the heavily fatted foods and fried foods should always be taken in moderation.

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CHAPTER IX

MINERAL SALTS IN NUTRITION

WHILE proteins, fats and carbohydrates have been stressed as all-important for the body, there are other substances having neither energy nor fuel value which are of vital importance for the growth and well-being of the individual. These are the mineral salts, those inorganic elements which form the ash constituents of the body. They may be present in simple form, as inorganic salts, or in complex organic combination. In the following Table is given a list of the chemical elements, showing their percentage amounts in the human body and the daily intake necessary for an average adult.

One notes at once that oxygen forms almost two-thirds of the body weight. Oxygen and hydrogen in the ratio of one part of oxygen to two of hydrogen form water, which constitutes 75 per cent of the body.

Protein, which contains oxygen, carbon, hydrogen, nitrogen and sulphur, is the only source of nitrogen. Phosphorus is to be found in the nucleus of the tissue cells. Iron also is present in all cells, including the red blood-cells or corpuscles, where it is responsible for the carriage of oxygen All these elements are necessary, and the percentage amounts as stated are no criterion of their physiological value. As examples of this, note the small amounts of iron and iodine, both of which, as will be seen later, are so essential for our physical and mental development. The greater part of the minerals of the body are to be found in the bones, the chief mineral constituents of which are calcium and phosphorus. A shortage of these elements in pre-natal life or in the early years is fraught with disastrous results Sulphur is secured through the intake of protein, being found combined with amino-acids, such as cystine and methionine. The lactalbumin of milk is very rich in cystine. Egg-yolk is rich in iron, and for phosphorus the best sources are the vitelline of egg-yolk and the caseinogen of milk. Certain foodstuffs do not supply minerals; they are carbohydrates and fats. For information as to the mineral content of foods, reference must be made to the appropriate Tables. Since the

these vitamins now on the market are manufactured. It is amazing how greatly people vary in their ability to digest and assimilate fat. Fat tends to delay digestion, which explains why a meal with fat gives a sense of satiety. In any form, fat, while prolonging digestion, adds considerably to the fuel value of the meal.

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Calcium requirements can only be studied by noting the amount of calcium taken in the food and the amount excreted in the urine and fæces. From the work of Dr. I. Leitch (1938) the average adult requirement of calcium is 0·55 grams per day, but later work by Steggerda and Mitchell in U.S.A. (1941) would suggest an even higher figure. The National Research Council Committee on Food and Nutrition recommend a daily allowance of 0·8 gram for adults, men and women, regardless of their activity. According to pre-war surveys many diets were well below this figure. Some authorities have stated that 50 per cent of pre-war dietaries were below 0·7 gram per head per day and 16 per cent were below the 0·55 figure. It may be accepted that from 1936 to 1943 the calcium intake of the population considered as a whole has slowly increased. In 1936–38, surveys of the average composition of the diet showed a calcium intake of 0·67 gram, in 1943, apart from the heavy or industrial workers, whose intake was 0·98, the average was 0·76 gram per head per day. The increased average intake, significant in 1943 and 1944 was due to a greater consumption and a better distribution of milk, vegetables and meat. Compared with the requirements scale used at the Rowett Research Institute which is practically identical with the new American standards based on age and sex distribution, the diets of the families surveyed were still slightly deficient in calcium. In 1944 the consumption of calcium had risen to an average of 0·86 gram in 1949 to 0·99 gram per head per day. Calcium is unevenly distributed among the various foods which make up an ordinary mixed diet. Many foodstuffs are very poor in calcium and a diet may, despite an apparent liberality, be lacking in this important element. A continued dietary deficiency in calcium subsequently results in a loss of calcium from the bony skeleton. To make good the loss of calcium from the blood and muscles, a call is made upon the calcium in the bones, where 99 per cent of the total calcium of the body is to be found.

The Calcium Requirements of Children.—Since it is extremely difficult to assess accurately the calcium requirements of growing children, it becomes the more imperative to have more than adequate supplies of calcium in the diet. Without the least doubt, the best foodstuffs in this respect are milk and cheese, followed, perhaps rather afar off, by the green

body does not store minerals to any extent, and since only small amounts are assimilated day by day, the *deficiencies of such* elements as calcium, phosphorus, iron or iodine become readily apparent. It is, therefore, of importance from a dietary point of view to know something of the physiological requirements for the various minerals, particularly in childhood and adolescence.

TABLE 30

CHEMICAL CONSTITUENTS OF THE BODY

Element	Per cent	Daily Normal Adult Intake in grams
Oxygen	65 0	—
Carbon	18 0	—
Nitrogen	3 0	—
Hydrogen	10 0	—
Calcium	1 50	0 7
Phosphorus	1 0	1 6
Sodium	0 15	4 6
Potassium	0 11	3 4
Magnesium	0 07	0 34
Sulphur	0 02	—
Chlorine	*0 16*	7 1
Iron	*0 015*	*0 016*
Iodine	Traces	0 00005
Copper, cobalt, fluorine, manganese, zinc	,,	—

Calcium and Phosphorus.—Calcium and phosphorus are of great importance for the development of the bones and teeth. A lack of these will result in a retardation in the growth of bone

to be found in many children. The lack of the usual signs, such as visibly deformed bones, narrow chest, etc., must never be taken as proof of the absence of rickets, for X-ray examination of the ends of long bones often shows that rickets exists. It is an entirely preventable disease. Its treatment demands that, in pregnancy a sufficient amount of calcium, phosphorus and vitamins A and D be taken by the mother and given to the child during the early years of its life.

retention. Fig. 22 presents graphically the results of such an experiment on a girl of 12 years of age. Upon such experiments is based the recommended allowance of 1 gram of calcium per day.

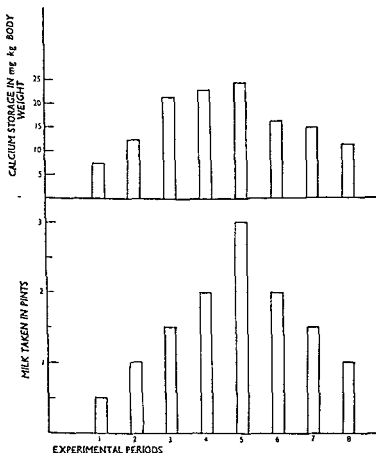


FIG. 22.—Showing the relationship between milk consumption and calcium storage in a girl aged 12 years (*From data by Sherman & Hawley, 1922*)

Children between the ages of 3 and 12 years should be given at least 1 gram per day, over 12 years, up to 1.4 grams per day. This can best be given in the form of milk—skimmed milk (1 pint = 0·70 g.) and cheese (1 oz. = 0·23 g.). Other foods

leafy vegetables. The need of a liberal supply of calcium for the young growing animal is shown by the tremendous increase of calcium compared with increase in weight. A rat at birth *weighs 5 grams and, on a normal diet, it will, in 3 months, weigh* 300 grams, a sixty-fold increase in weight. In the same period it will have raised the total calcium content of its body 800 times. It is admittedly difficult to determine for any growing body the optimal amount of any mineral necessary for optimal growth Reference has already been made to the value of experiments covering three or four generations. Sherman and Campbell (1935) carried out an experiment covering forty generations in rats to show to what extent a surplus of calcium would improve growth and vitality. Briefly, the procedure was as follows: one diet consisted of five-sixths ground whole wheat and one-sixth dried whole milk with the usual amounts of water and salt: the other diet differed from the first by the addition of calcium carbonate to raise the calcium intake from 0·68 gram to 1·36 grams; these are the amounts of calcium in a pint and a quart of milk respectively. On the part of the males the beneficial results were manifested by slightly greater weight, greater vigour and later senescence; on the part of the females, there were added to these benefits a slightly earlier maturity and a lower death rate among their litters.

More important, however, are the results of experiments on growing children. By changing the amount of milk in the diet of children of ages varying from 4 to 12 years, it has been shown that when the amount of calcium given was 1·36 grams, i.e. equal to 1 quart of milk, the retention of calcium was markedly increased above that obtained with an intake of 0·68 gram of calcium. Greater improvement was obtained in both cases when the calcium was given in the form of milk. This result indicates the importance of giving both calcium and phosphorus in their natural form and in approximately the correct proportion. Reference must here be made to a most valuable type of experiment on pre-school children, boys and girls, 3 to 5 years of age (Daniels, *et al.*, 1935). To an *adequate diet was added vitamins A, D and C in the form of* cod-liver oil and orange juice. The daily intake of calcium varied between 0 77 and 0 90 gram, and the retention of calcium varied between 9 and 12 milligrams per kilogram daily. Increased amounts of calcium did not appreciably improve the

in the maternal milk, (0 03 g. per cent). Cow's milk contains 0 12 g. per cent of calcium, vitamin tablets 0·25 g. calcium phosphate.

In dealing with mineral requirements, as always, availability must be considered. Milk, milk products and bread made from fortified flour because of their predominance in dietaries, supply the greater part of the daily calcium and phosphorus requirements. Vegetables must not be neglected; the availability of calcium is excellent in beans, cauliflower, cabbage, broccoli and kale. Spinach, despite its large content of calcium, cannot be regarded as a good source of this element because of the presence of oxalic acid. Rhubarb is also equally doubtful in this respect.

Fish, fresh, cured and canned, is an excellent source of these minerals Nuts also have a rich content but the availability of the mineral salts in them is probably limited.

Iron.—Iron is that constituent of hæmoglobin upon which the carriage of oxygen depends. The hæmoglobin is found in the red corpuscles of which there are many millions in the blood. By means of these blood cells, oxygen is carried to every part of the body and there transferred to the tissue cells, many of which also contain minute amounts of iron in their structure. It is rather surprising that so important an element as iron should be found in comparatively small amounts in our foodstuffs. Iron absorbed from the intestine is stored to a limited extent in the liver, bone marrow and the spleen So limited, however, are the stores of iron in the adult body that, to make good any loss of the element, there should always be an adequate supply of iron in the diet. In men, the normal loss of iron is very small, just as the amount utilized day by day is small, nevertheless, in view of its importance in oxidative processes within the body, the optimal requirement must constantly be maintained. This presents no dietary difficulty In women, [illegible] es of iron [illegible] rly in the [illegible] This can [illegible] reatment.

Iron Requirements of Adults and Children.—The iron requirement of adults is about 12 mg. per day; for children it varies from 6 mg. at 1 year to 12 mg. at 12 years; for adolescents and pregnant and nursing mothers it is 15 to 20 mg. per day. The iron requirement of normal adults is well cared for if

suitable for the supply of calcium are kale, cabbage, cauliflower, lentils, turnips, carrots, cheese and almonds.

In pregnancy and lactation an intake of 1 and 2 grams per day respectively is desirable. During lactation the amount of calcium required by the child at the breast increases from about 0 2 to 0 4 gram per day, from birth to the sixth month. The aim should be to secure for the mother 1 quart of milk daily to make up to the calcium requirement of 2 grams per day by the use of calcium rich foods (see B.M.A. Report, 1950).

TABLE 31

CALCIUM AND PHOSPHORUS CONTENT OF COMMON FOODSTUFFS

Compiled from *Nutritive Values of War-time Foods*, M.R C., 1945, and *Chemical Composition of Foods*, McCance and Widdowson, 1940

Foodstuff	Calcium mg /100g	Phosphorus mg /100g	Foodstuff	Calcium mg /100g	Phosphorus mg./100g
Cheese (ave.) . .	800	450	Rhubarb (raw) .	103	21
Milk (whole) .	120	95	Sultanas (dried) .	52	94
Egg (whole) . .	56	218	Almonds . .	247	442
Bread (white) .	23	73	Currants (dried) .	95	40
,, (wholewheat)	30	213	,, (black, raw)	60	43
,, (National fortified, 85 % extr). .	108	—	,, (red, raw) .	35	29
			Dates (dried) . .	68	64
			Figs (dried) . .	234	91
Beef . . .	10	28	Lemons (whole) .	107	20
Oatmeal . .	55	380	Beans, butter (raw)	85	318
Fish (with edible bone)	40	200	,, haricot (raw)	180	309
Herring . .	100	272	Watercress . .	222	127
Apricots (dried) .	92	118	Mustard and cress .	66	65
,, (fresh) .	17	21	Kale . .	200	60
Blackberries . .	63	23	Treacle (black) .	495	30
Oranges .	41	24	Sardines (oil) . .	400	683
Prunes . . .	38	83			

Calcium therapy demands an adequate amount of vitamin D. If milk cannot be taken, the oral administration of calcium is the best for all practical purposes. It is wise to note that the administration of excess calcium without a supply of vitamin D is likely to do more harm than good. The rational method is to give about 0·5 gram with 500 to 1000 international units of vitamin D, depending upon whether the vitamin D is required for prophylaxis or for treatment.

In pregnancy calcium plays a very important part. At birth the child's body is a veritable reservoir of calcium; the body of an average baby may contain about 80 grams of calcium, all of which is held in reserve because of the comparative lack

concluded "that in group studies the incidence of anæmia had not increased but that there was still an undue amount of preventable anæmia which may be due to a lack of hæmopoetic factors, especially iron in the diet". The anæmia was found particularly in infants and young children, pregnant women, housewives and certain occupational groups Comparing the results of blood protein estimations on home blood donors with those obtained from Canadian soldiers, they found a significantly higher figure for the Canadian soldier which, in their opinion, was due to the higher animal protein intake in the military diets. The committee concluded: "An effort should be made to reduce the considerable proportion of low levels of hæmoglobin which some groups still reveal—e g. young children, pregnant women, and persons at the lower economic level." Professor Stanley Davidson, of Edinburgh, is of the opinion that the national bread, with its higher iron content, was largely responsible for the rise in the hæmoglobin content in infants and school children during 1943–44. Dr. Helen Mackay of the Queen Elizabeth Hospital for Children, London, while not accepting the national loaf as the one and only factor, agrees that the reduction in the incidence of anæmia in children is due to an improvement in diet. Both authorities agree that anæmia in children is still extremely common and that the best therapeutic results are obtained by giving the children an iron preparation. The preparation used in these investigations was 3 grains of ferrous sulphate or the preparation Fersolate (Glaxo), which is a pill containing 4 grains of ferrous sulphate, with small amounts of copper and manganese. An interesting scientific point is that copper, an element present in very small amounts in the body as well as in foodstuffs, is of value in stimulating the utilization of iron and the production of hæmoglobin, the complex oxygen-carrying compound found in the red blood cells.

Nutritional Anæmia.—Two types of anæmia are of nutritional interest: (*a*) the hypochromic in which there is a deficiency of hæmoglobin and therefore of iron in the red blood corpuscles; (*b*) that in which there is a marked failure of the bone marrow to develop red blood corpuscles.

(*a*) Hypochromic Anæmia.—Many years ago it was noted that mice fed on a diet consisting solely of milk developed a type of anæmia, recovery from which could be obtained only

an adequate mixed diet be taken, that of children and nursing mothers requires some comment.

The child at birth has a large store of iron in its body, mainly in the liver, which should serve as an iron reserve during lactation. It was Bunge who, many years ago, was responsible for the statement that, at birth, the child's body contained a store of available iron sufficient to supply its need for iron throughout the period of lactation. In 1933 Ramage and others estimated the amount of iron in the human embryonic liver. They found that during the latter half of pregnancy the total iron content of the liver of the fœtus rose from approximately 15 mg. to 75 mg. The rate of depletion of this iron reserve in the infant depends upon the degree of prenatal storing, the amount of iron in the mother's milk and the degree of breakdown of superfluous red blood cells by which iron is released. It was usual in the past to regard a fall in the hæmoglobin of the blood during the first six months of life as normal, but it has been proved that *the recovery from the so-called 'normal'* fall of hæmoglobin in the second and third month is more rapid and [illegible]

are allowed to suffer a diminution in the hæmoglobin content of their blood. The iron requirement up to 1½ years is not less than 0·5 mg. per kilogram of body weight.

Hæmoglobin Levels as evidence of the Nutritional State.—Nutritional deficiency of children as well as of pregnant and non-pregnant women can be assessed by determining the hæmoglobin concentration of the blood. The 100 per cent standard (Haldane) for hæmoglobin estimation is 14·8 g. Hb. per 100 c.c. of blood. At the request of the Ministry of Health, the Medical Research Council undertook to obtain evidence of the nutritional state of the people of this country in the *fourth year* of war. A special committee considered the problem from dietary, medical, sociological and psychological aspects. It was previously realized that a long-continued iron deficiency could aversely affect the protein content of the blood. They therefore investigated hæmoglobin and protein levels in the blood of 13,000 adults and 8,000 children and compared the results with those obtained before and during the war. They

secretion, as happens in pernicious anæmia, the individual is unable to elaborate the hæmopoietic principle from the extrinsic factor present in a normal diet. The individual must therefore be supplied with this hæmopoietic principle which may be vitamin B_{12} and is obtained from the liver, liver extracts, brain tissue, etc. In pernicious anæmia where there is a lack of the intrinsic factor, hydrochloric acid in the gastric juice and available iron in the body, the treatment of the condition demands the use of a combination of all these. Vitamin B_{12} when injected parenterally, that is into muscle, results in a rapid restoration of the normal maturation processes of bone marrow (Lester Smith; Ungley; Mollin and Dacie—1950) Interesting in the treatment of megaloblastic anæmias is the part played by folic acid.

Folic acid, originally isolated from spinach, is found in liver, kidney, yeast and many plants; it was synthesized by Angier *et al.* in 1945 and is now known by the name of pteroylglutamic acid; this substance stimulates the normal production of red cells, leucocytes and platelets in many animals. It has naturally been extensively tried out in the treatment of anæmias of man and has been found to be effective in the treatment of megaloblastic anæmias such as pernicious anæmia, nutritional megaloblastic anæmia and megaloblastic anæmia of pregnancy.

While folic acid is specific for stimulating normal hæmopoietic activity it is not so effective in treating lesions associated with these anæmias, e.g. sub-acute degeneration of the cord. The mode of action of all these factors which are to-day so intimately associated with the cure or treatment of anæmias is not yet fully understood. Nevertheless, folic acid has been shown to be especially valuable in the treatment of megaloblastic anæmia of pregnancy (Spies *et al.*) Ungley and his co-workers (1950) have also recently shown that in macrocytic anæmia associated with pregnancy, while vitamin B_{12} has little or no effect on the blood picture, folic acid however has a definite if not dramatic effect. The results of the work of Patel and Kocher (1950) in India supporting the beneficial effect of B_{12} in macrocytic anæmia of pregnancy are at present regarded asnot convincing in that the presence of a nutritional anæmia may have complicated the issue.

In a paper by Taylor and Chhuttani (1945) the relationship

on the addition of egg-yolk to the diet. This fact is the basis of all scientific work which has shown that recovery from a condition of anæmia, characterized by a loss of hæmoglobin from the red blood cells, is dependent upon a normal amount of protein, iron and copper in the blood. This type of anæmia is called hypochromic because of the lack of the iron-containing pigment—hæmoglobin—in the blood corpuscles. Associated with this condition, and by some believed to be a causative factor, is a failure of gastric function due to a deficiency of hydrochloric acid in the gastric juice. The diets of patients showing this type of anæmia are often deficient in animal protein (e.g. milk, eggs) and vegetables. In hypochromic anæmia there is no evidence that any specific substance necessary for the formation of hæmoglobin is lacking from the gastric juice. It would appear then, that nutritional anæmia is due in the first place to a lack of iron in the diet and in the second to a lack of hydrochloric acid in the stomach, where the mineral acid is necessary for the liberation of iron from the food and its transference from the ferric to the ferrous state. This type of anæmia is found in infants over six months of age and also in women as a result of iron loss during menstruation.

(b) **Pernicious Anæmia.**—In this type of anæmia there is a marked diminution in the number of red blood corpuscles in the circulating blood, and many of them are much larger than normal, hence the term macrocytic anæmia; both types of cell, large and small, have more than their normal supply of hæmoglobin. It is well known that bone marrow, in order to function normally in the production of red blood cells, must receive from the liver a substance called the "hæmatinic principle". This substance, which is stored in the liver, was discovered by Minot and Murphy in the U.S.A. in 1926. It depends upon two factors for its formation, one, the intrinsic factor, in the mucosa of the stomach, the other, the extrinsic factor of Castle, supplied by the food; the chief sources of this latter factor are beef, rice polishings, marmite and wheat germ.

The work of Berk, Castle *et al.* (1948), which suggested that the function of the intrinsic factor is to assist the absorption of vitamin B_{12}, has been supported by Ungley and his co-workers in this country and Ternberg and Eakin in America. Where the intrinsic factor is lost or greatly diminished in the gastric

secretion, as happens in pernicious anæmia, the individual is unable to elaborate the hæmopoietic principle from the extrinsic factor present in a normal diet. The individual must therefore be supplied with this hæmopoietic principle which may be vitamin B_{12} and is obtained from the liver, liver extracts, brain tissue, etc. In pernicious anæmia where there is a lack of the intrinsic factor, hydrochloric acid in the gastric juice and available iron in the body, the treatment of the condition demands the use of a combination of all these. Vitamin B_{12} when injected parenterally, that is into muscle, results in a rapid restoration of the normal maturation processes of bone marrow (Lester Smith; Ungley; Mollin and Dacie—1950) Interesting in the treatment of megaloblastic anæmias is the part played by folic acid.

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between animal protein and macrocytic anæmia has been demonstrated in Indian subjects living on meat and vegetarian diets. The tropical macrocytic anæmia, found only in the vegetarian group, was present when milk, fresh fruit and vegetables were all much reduced in a vegetarian diet. The meat eaters suffered from the hypochromic type of anæmia. In the groups examined the incidence of severe anæmia was very much greater in vegetarians than in meat eaters. The investigators noted accurately the dietary intake of the two groups and concluded that " the anæmia, in its type and severity, was closely and regularly related to the diet consumed ". The *evidence presented clearly indicates that a nutritional anæmia* in children and women exists in India. With meat and liver in short supply, during and after the war, it is not easy to ensure the best diet possible to prevent anæmia in pregnant or nursing mothers and in growing children. The public must be educated to the importance of the need of mothers and children for their fair share of meat in the family dietary. To combat the deficiency in iron for these vulnerable groups, the infant should receive, if artificially fed, iron incorporated in dried milk (from six months onwards) meat as mince and iron in liquid form. The Department of Health for Scotland suggests that an iron mixture should be given to babies whether breast or bottle fed. According to Mackay and Goodfellow there is one foodstuff which can produce a rapid cure of nutritional anæmia in children over one year, and that is liver in daily amounts of 4 oz.; this supplies 16 mg. of iron. This statement was made in 1931; while the iron content of liver has not appreciably changed since then, the cost and supply of liver unfortunately have!

In the treatment of cases of hypochromic anæmia, nothing is gained by giving too much iron, in fact, iron in large doses is known to be toxic to children. It is also not justifiable to assume that iron will always be absorbed by anæmic patients given optimal doses, for failure in absorption is often the fault. It is generally accepted that inorganic preparations of iron are superior to organic, the best probably being ferrous sulphate, 2 gr. every day, of which 10–15 per cent may be absorbed. There are several oral preparations on the market which contain ferrous sulphate, copper, manganese and sometimes yeast; parenteral preparations given by intramuscular or intravenous



A



B



C



D

Fig 23 —Myxœdema treated for thirty years with thyroid A, aged 65, before treatment B, five weeks later C, fifteen months later D, aged 94 [*After Raven, by courtesy Brit Med*]

the stomach, converted into a ferrous chloride in which form it is suitable for absorption from the intestine. Some of the iron, however, may be oxidized to the ferric state and thus, combining with sulphides, phosphates and phytic acid, form insoluble and non-absorbable compounds. With a mixed and adequate diet so much iron is taken that the fear of loss by phytic acid containing foods, except in the case of young children and women in the lower income groups, may be disregarded. The iron in organic combination such as hæmoglobin is not utilized by the body. The foods which are good sources of iron are shown in Table 32.

Iodine.—The indispensability of iodine in nutrition is unquestioned. It is required by the thyroid gland for the production of its active principle, thyroxine. When there is a deficiency of iodine due to its lack in food or in water, the thyroid gland becomes enlarged giving rise to the condition known as goitre. Where the thyroid function declines in adults, *a condition known as myxœdema appears. In myxœdema the* basal metabolism is reduced, the subject becomes slow both mentally and physically, the hair loses its lustre and falls out, the skin becomes dry and immobile, and obesity results. All these signs disappear following the administration of thyroxine or extract of the thyroid gland. The transformations which can be effected by treatment are in many cases dramatic (Fig. 23). Children who suffer from a failure in the embryonic development of the thyroid gland, due to a lack of iodine in ante-natal life, are stunted in growth, extremely ugly in appearance and often imbecilic. These children, cretins, if treated early in life by continuous ingestion of small amounts of iodine in the form of iodide, or by the therapeutic use of thyroxine, can be almost magically transformed.

Goitre is endemic in many parts of the world, e g. the Himalayan regions of India, certain parts of the N.W. territories of the U.S.A., in New Zealand, Switzerland and the United Kingdom. It is generally attributed to a lack of iodine in river water. *The sea is the great source of iodine.* The amount of iodine in rivers depends upon the geological formation of the country through which they run. In mountainous regions and in the plains supplied by glacial water, and also in certain lake regions, iodine is deficient in the water and the soil All who live in, or obtain their domestic water from such

areas will suffer from iodine lack, and the meat and milk of cows and goats in these areas will also be lacking in this most valuable element. A considerable amount of evidence has been obtained concerning the deficiency in iodine of certain of the rivers of Great Britain. In the areas supplied by these rivers a definite incidence has been recorded of enlarged thyroid and also of goitre in boys and girls between 11 and 18 years of age. Working on records of the Board of Education Goitre Survey of 1924 Dr. Stocks found goitre markedly prevalent in North Oxfordshire where the iodine content of the water was stated to be 1·4 to 3·0 μg. per litre. In the southern area of Oxfordshire and in Windsor in Berkshire, the iodine content of the water supply was 10 to 52 μg. per litre, and no evidence of endemic goitre was found. Miss B. W. Simpson of the Rowett Research Institute, Aberdeen, has examined samples of drinking water from Cornwall to Caithness and her results have been correlated with the clinical evidence of hyperplastic or enlarged thyroid in many of the river areas examined. The areas of high incidence in England are Cornwall, Devon, Somerset and Oxfordshire in the South-west, Derbyshire and Cheshire in the Midlands, the Isle of Wight in the South and Durham and Northumberland in the North (See Table 33). In Scotland two areas are prominent—Inverness-shire and Dumfriesshire. In certain of these areas, such as Somerset and Derbyshire, the incidence of goitre has been reduced, due to extensive alterations in their water supplies. The incidence is of the order of 10 to 30 per cent in the girls of 15 to 17 years and approximately a third of those figures for boys of the same age. It must be emphasized that an enlarged thyroid gland does not imply an established goitre. The aim of the investigations being carried out by the Medical Research Council is the elimination of goitre and "the control of those forms of mental and physical degeneracy, such as cretinism, mutism and iodicy, which are dependent upon thyroid insufficiency". Goitre is due to a combination of factors, chief among which is the part played by calcium, magnesium and fluorine in reducing the availability of iodine.

The treatment of goitre, due to a deficiency of the hormone or active principle of the thyroid gland, is essentially a nutritional problem. Thyroid gland of the sheep was first administered for the treatment of myxœdema in this country by Dr. Murray in 1891. To-day dried thyroid or thyroxine is given.

the stomach, converted into a ferrous chloride in which form it is suitable for absorption from the intestine. Some of the iron, however, may be oxidized to the ferric state and thus, combining with sulphides, phosphates and phytic acid, form insoluble and non-absorbable compounds. With a mixed and adequate diet so much iron is taken that the fear of loss by phytic acid containing foods, except in the case of young children and women in the lower income groups, may be disregarded. The iron in organic combination such as hæmoglobin is not utilized by the body. The foods which are good sources of iron are shown in Table 32.

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recommended that a similar measure should be adopted in this country; in 1947, 0.13 mg. of potassium iodide was added to vitamin tablets for nursing mothers. The treatment of school children in goitrous areas, under medical or school supervision has been productive of excellent results, but supervision must always be exercised in such treatment in order to prevent the administration of iodine to adolescents who may be prone to excessive activity of the thyroid gland.

Human Requirements.—Iodine, a trace element, is essential for human nutrition in amounts which are not precisely known; the amount suggested for adults is 0 15 to 0 3 mg. per day; children probably require three times this amount. More important at present is it to realize the need of children and pregnant women for this element and if in a goitre area to treat them accordingly.

Foods most noted as sources of iodine are—fish, milk, leafy vegetables, potatoes and carrots. Seaweed contains up to 10 mg. per 100 grams; fish 0 01 mg. per 100 grams.

That all these elements are of extreme value in reproduction is seen by comparing the results of feeding defective mineral foodstuffs to normal animals.

The Utilization of Mineral Salts.—Utilization depends upon absorption by the intestinal mucous membrane. A lack of any mineral in the body may be due to a dietary deficiency or a faulty absorption of the mineral in question. A faulty absorption of any element cannot generally be improved merely by increased ingestion of the mineral salt. Mineral salts do not need to be broken up by digestive processes, but in foods they are often in combination with proteins, fats and carbohydrates, so that the food has to be thoroughly digested in order to free the mineral salts for absorption. The facility with which the salts are taken up during digestion depends upon the type of food in which they are presented to the body, e g. the calcium of milk is far better absorbed than that of vegetables; the mineral elements in egg-yolk are well absorbed; iron is better absorbed in solution than in the form of an insoluble compound. It is rather important that fat digestion should be normal if the minerals are to be absorbed in their correct proportions; any inability to assimilate fats should indicate that, unless steps are taken to correct the disability, or, fatty substances are reduced in the diet, there will undoubtedly be

The discovery, by Baumann in 1895, of iodine in the thyroid gland and its isolation from thyroxine by Kendall in 1914, led to the idea that *potassium iodide may be a remedy for goitre* in children. The idea was acted upon. The most successful of the early experiments in the iodide treatment of goitre in children were conducted in Switzerland in 1918 by Professor Klinger of Zurich and in the State of Ohio in U.S.A. in 1917 under the supervision of Drs. Marine and Kimball. In Switzerland the incidence of goitre in school children in three Cantons examined

TABLE 33

INCIDENCE OF ENLARGEMENT OF THE THYROID GLAND IN CHILDREN, AGED 11 TO 15 YEARS, FROM FOUR AREAS IN WHICH THE DRINKING WATER VARIED GREATLY IN IODINE CONTENT

Area	Iodine Content of Water (μg per litre)	No of Children examined	Total No of visible Thyroid Glands	Percentage incidence of visible Thyroid Glands
Okehampton, Devon	1 1 (very low)	298	78	26 2
North Oxfordshire .	2 0 (low)	451	81	18 0
Windsor, Berks .	10 1 (high)	461	31	6 7
Maldon, Essex	50 2 (very high)	527	13	2 5

From Table I of *M.R.C. Memorandum* (1948), No. 18, H.M S O.

fell in three years from 87 to 13 per cent. In the State of Ohio, 5 milligrams of potassium iodide were given twice weekly for one month and repeated six-monthly from 1917 to 1920. In an area where the incidence of goitre in school children was approximately 50 per cent, of 2000 taking the salt only 5 had enlarged thyroids, while, of 2000 untreated children, 500 showed symptoms and signs of thyroid enlargement. Modern prophylactic treatment is carried out in many countries, including Switzerland, Poland and the U.S.A., by the use of iodized table salt, containing 10 milligrams of potassium iodide per kilogram of salt. In 1944 the Medical Research Council

Iodine.—This mineral, found in the body and in foods in such extremely small amounts and so vitally important for physical and mental health, is to be found in codfish, salmon, indeed all fish, cod-liver oil, milk and leafy vegetables.

TABLE 34

FOODS RICH IN MINERALS

Calcium	Phosphorus	Iron	Iodine
Cheese	Cheese	Liver	Fish
Milk	Egg-yolk	Egg-yolk	Crab, lobster
Egg-yolk	Fish	Treacle (black)	and oysters
Treacle (black)	Whole grains	Lentils	
Kale		Meat	

Foods deficient or lacking in mineral salts are: butter, sugars, honey, white flour, orange and grape juice, highly purified starches.

Base-Forming Elements	Acid-Forming Elements
Sodium	Chlorine
Potassium	Sulphur
Calcium	Phosphorus
Magnesium	Carbon
Iron	

ACIDITY AND ALKALINITY OF FOODS DETERMINED BY THE REACTION OF THE ASH

Acid	Alkaline
Meat	Milk
Fish	Fruit juices (most)
Eggs	Peas
Cheese	Beans
Cereals	Root vegetables

It is usual in supplying mineral salts to go beyond the needs of the body; this is a wise procedure in view of the various factors which tend to hinder the assimilation of the mineral salts We may sum up what has been said on the supply of mineral salts as follows :—

Milk should form the basis of the diet. Adults should take a half to one pint per day; children up to 14 years and nursing

some loss of mineral elements from the body. Important points in this respect are the balance between base-forming (sodium, potassium, calcium, etc.) and acid-forming elements (sulphur, phosphorus, chlorine, etc.). An excellent example of this is afforded by calcium and phosphorus: normal utilization of these two elements is secured when they are in the ratio of 1 : 1 in the food taken. This is approximately the ratio of calcium to phosphorus in milk. Again, iron utilization has been shown to be improved by taking foods rich in calcium, such as milk. In this connection vitamins play a part: vitamin D, for instance, is necessary for the maintenance of the correct percentage of calcium and phosphorus in the blood and the utilization of these elements in the formation of strong bones and teeth. One of the most important factors in preventing a normal absorption of iron is intestinal putrefaction arising from faulty protein digestion. It is clear, then, that for the best utilization of mineral salts, the alimentary tract must be in order, and the diet should contain liberal amounts of milk, *and of those fruits and vegetables which are rich in vitamins.*

Of the elements mentioned, only four are at all likely to be deficient in average diets; these are calcium, phosphorus, iron and iodine, and of these four, the one usually found most deficient is calcium. The distribution of the minerals, calcium, phosphorus and iron, in foods will be seen in Table 34.

Calcium.—The first point of note with regard to calcium is its uneven distribution in all foods with the exception of milk and milk products. Milk, cheese and fortified national bread, form the crux of the problem of calcium supply. Generally vegetables, fruits and whole grains are satisfactory sources of calcium; but meat, fish, sugar, fat and highly-milled cereals are definitely lacking in this element.

Phosphorus.—It is interesting to note that, with few exceptions, our foodstuffs are excellent sources of phosphorus, the best being cheese, vegetables, meats, eggs and whole grains. *The exceptions are butter and sugar, which contain none.*

Iron.—This element is conspicuous by its absence in most foods. *It is not found in butter, vegetable oils and sugar; it is* found in very small amounts in fish and milk. Certain cheeses contain iron, others do not. Most vegetables are good sources, but the best are egg-yolk, liver, whole grains, lentils, beans, kale, peas and certain fruits.

disease, pellagra, in man. Later it was shown that the prevention and cure of scurvy was possible by means of a water-soluble vitamin which was then called vitamin C. Following on this was the discovery that a fat-soluble vitamin was responsible for the cure of rickets, to this accessory factor the name vitamin D was given, and so was introduced the alphabetical nomenclature of vitamins. This alphabetical nomenclature is rather unfortunate, and the modern tendency is to dispense with it and to call each factor by its chemical name wherever the structure of the material is known. Some 16 or 17 vitamins have been distinguished according to their different properties and mode of action. A classification of these and the principal effects of deficiencies occasioned by their lack is shown in Table 35.

VITAMIN A (Axerophthol)

This is one of the fat-soluble vitamins which is found in food associated with animal fats, but not with lard and vegetable fats, and also with the green and yellow pigments of plants Vitamin A is partially manufactured in the animal body from the yellow pigment carotene which is present in land and marine plants; carotene belongs to a class of carotenoids soluble in fat solvents but not in aqueous solutions; these carotenoids are provitamins. It forms the colouring matter of carrots, and is present in the green primitive plants which are to be found in all oceans. Animals and fish eat these plants, make the vitamin from carotene and store it in the liver and body fats. This is especially true of fish; the older the fish the richer is their store of vitamin A.

One of the functions of vitamin A is to promote the growth and development of the body. A study of the growth curve of rats fed on diets with and without vitamin A clearly shows the part played by the vitamin in respect of growth. When a rat, previously fed on an adequate diet, is given a diet adequate in all respects except for vitamin A, it continues to grow for about four weeks depending upon the amount of vitamin A stored in the body. Upon depletion of this store, there is a dramatic fall in weight. If, when this has become manifest, vitamin A be added to the diet in the pure form or as butter fat or egg-yolk, the weight curve is rapidly restored to normal (Fig. 25). If this is not done, death will rapidly ensue. It

Hopkins showed that rats did not grow if given a purified diet of caseinogen (milk protein), starch, salts and lard, but did grow to full size if 3 c.c. (approx. 1/10 oz.) of milk were added daily to such a diet (Fig. 24). Three cubic centimetres of milk contain 0·08 gram of solids, of which the greater part is already present in the artificial diet. This led to the discovery of a vitamin, soluble in milk fat, to which the name "fat soluble vitamin A" was given. McCollum and Davis,

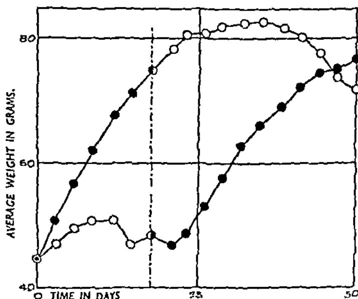


FIG 24.—Two curves showing growth of rats with and without "Vitamin A". Lower curve (up to 18th day), eight male rats on pure dietary; upper curve, eight similar rats taking 3 c c. of milk each a day. On the 18th day, marked by vertical dotted line, the milk was transferred from one set to the other. [*Sir Frederick G. Hopkins*]

in 1915, found that rats fed on a synthetic diet, containing butter fat to supply the fat-soluble vitamin, did not grow satisfactorily, and that they required another factor, which they named "water-soluble vitamin B". Before long, experiments had made it necessary to differentiate two factors in the complex called vitamin B, namely B_1, a vitamin which prevented polyneuritis in birds, and B_2, a vitamin discovered by Goldberger and others in U.S.A. in 1926, and found to be of value in preventing a certain type of dermatitis in rats and the skin

was in the course of such experiments that other signs of vitamin A deficiency were noticed. Characteristic eye trouble always developed; the lachrymal gland no longer secreted tears, the

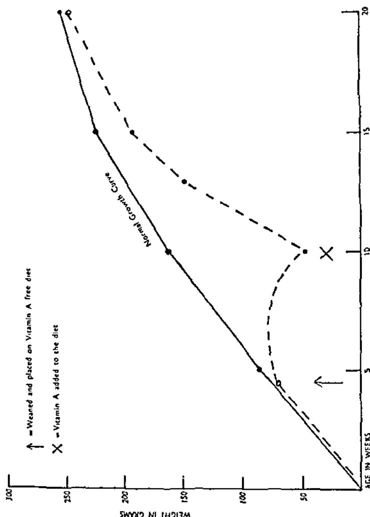


Fig 25 —Effect of vitamin A on growth in the rat

conjunctiva of the eyeball became dry and conjunctivitis developed leading to swollen and inflamed eyelids With further development of the deficiency the cornea of the eye may

TABLE 35

THE VITAMINS AND THE PRINCIPAL EFFECTS OF DEFICIENCY

THE VITAMINS

FAT-SOLUBLE

- Vitamin A, epithelial metaplasia, animals and man
- Vitamin D, antirachitic, animals and man
- Vitamin E, anti-sterility, rat, mouse, fowl, anti-dystrophic, animals
- Vitamin K, blood coagulation, animals and man

WATER-SOLUBLE

- Ascorbic acid; antiscorbutic, guinea-pig, primates, man
- Flavinoids (vitamin P), capillary resistance, guinea-pig, ? man
- Vitamin B complex
  - Thiamine, anti neuritic, pigeon, fowl, man
  - Pantothenic acid, anti-*grey hair*, *rat*
  - Riboflavin; *chick*, *rat*, *pig*, *dog*, man, multiple lesions in deficiency (ariboflavinosis)
  - Nicotinic acid, Nicotinamide, man; pellagra-preventing dog; anti-black tongue
  - Pyridoxine, chick, pigeon, rat, anti-dermatitis dog, pig, anti-anæmic
  - Biotin; rat, man, egg-white injury protective factor
  - *p*-Amino-benzoic acid; rat, chick; anti-achromotrichia
  - Lipotropic factors:
    - Choline; *rat, ? man*
    - *Inositol*; *rat, ? man*
  - Anti-anæmic factors:
    - *Folic acid*; chick, dog, man
    - Vitamin B_{12}, monkey, man



Fig. 96.—Xerophthalm [illegible]

[illegible] of ophthalmia of dietary origin, and was cured by administration of fat-soluble A, as butter and cod-liver oil The sight of the left eye was destroyed

[To face page 166

become thickened and opaque leading to blindness. Several diseases of the eye mentioned in the ancient medical literature of China, Arabia and Egypt were undoubtedly due to vitamin A deficiency. If young children and young animals are fed over long periods on diets insufficient in vitamin A, they cease to grow, suffer from night blindness and an infective condition of the eyes known as xerophthalmia (Gk. xeros = dry, *ophthalmos* = the eye). This last condition when it leads to distinctive invasion of the cornea with opacities, is called keratomalacia. Xerophthalmia is characterized by swelling and thickening of the cornea and conjunctivitis and will respond to no treatment which does not include vitamin A (Fig. 26). It was quite common in Denmark during the Great War, 1914–18, when the Danes substituted margarine for the butter which they sold to Germany and other countries.

Night blindness has been observed in endemic form in many parts of the world. Experiments on rats have shown that this disease is one affecting the protective visual purple in the retina of the eye. Rats on a vitamin A deficiency diet, placed in the dark after a definite time exposure to bright light, show a subnormal regeneration of their visual purple. *This can be tested by noting the ability of the rats to jump* from a table into a cage in a dim light after exposure to bright sunlight or any bright light. The abnormal rats fail to see the edge of the table and fall to the floor. In one hour after giving them vitamin A they can spring into the cage as quickly as their normal fellows. This form of night blindness was quite common during the Great War (1914–18) among Austrian prisoners of war in Russia and was studied by various Austrian physicians, themselves prisoners. They found the disorder to be a frequent one amongst Russian peasants in peace time, especially during the period of religious fasting before Easter. During this period all animal foods were forbidden, including fish, eggs, milk and butter; the diet enjoined was strictly vegetarian, and included fats and oils of vegetable origin only. Lightly-cooked liver or cod-liver oil were the popular remedies. One observer found that the disease could be cured in about 4 days by giving cod-liver oil for 2 or 3 days, another, by giving 3 eggs daily for 3 days. Night blindness is also known in Newfoundland where, because of poverty and a poor consumption of fresh fish, most of the fish being salted or cured, not

nly night blindness is prevalent, but beri-beri. During the arlier months of the world war (1939–45) considerable interest was aroused in the question of the relationship between vitamin intake and dark adaptation. It is maintained by many hat, while such a relation exists, the dark adaptation test cannot e accepted as entirely reliable for the diagnosis of vitamin A

TABLE 36

VITAMIN A IN FOODS

From *Nutritive Value of War-time Foods, M.R.C.*

I.U. per 100 grams.

	Edible portion	As purchased
Butter	4,000	4,000
Margarine (vitaminized)	2,000	2,000
Milk, summer	140	140
,, winter	70	70
,, condensed	370	
,, human	300	
Egg, whole	1,000	880
,, yolk	3,000	3,000
Cheese, cheddar	1,300	1,300
Carrots, (c)	10,000	9,500 (5%)
,, (c) (Sept.)	20,000	16,000 (20%)
Parsley (c)	13,000	13,000
Turnip tops (c)	10,000	7,500 (25%)
Watercress (c)	5,000	4,250 (15%)
Spinach (c)	13,000	9,750 (25%)
Cabbage (c)	900	630
Tomatoes (c)	3,000	2,550 (15%)
Halibut liver oil	5,000,000	5,000,000
Cod liver oil (M. of Food)	100,000	100,000
Liver, calf	4,000	4,000
,, ox	15,000	15,000
,, pig	5,000	5,000
,, sheep	45,000	45,000
Apricots (dried)	5,000	5,000
Prunes (dried)	2,500	2,500

c = carotene.

Note—The figures in brackets represent the percentage wastage in the foodstuff as bought. See Table of vitamin C foods.

the vitamin A may be provided by carotene which is not as readily absorbed as the fully formed vitamin

While formerly it had been assumed that vitamin A was formed from carotene in the liver, it has recently been demonstrated that β-carotene is transformed to vitamin A in the small intestine (Sexton *et al.*, 1946; Goodwin *et al*, 1948). Kon and his fellow workers have shown that when β-carotene is given by mouth to vitamin A deficient rats, vitamin A appears in the wall of the intestine within 15 minutes, but failed to appear in the blood or liver before 45-60 minutes have elapsed (Thompson, Ganguly and Kon, 1949; Thompson *et al*, 1950).

Variations in the vitamin A value of dairy produce result from seasonal changes in the feeding of farm stock, which means that the vitamin A content of milk, butter and eggs is lowest at the end of the winter season and highest during the summer and autumn. To prevent deficiencies in children's dietaries the best and most reliable method is to give any liver-oil preparation. Cod-liver oil, which of all liver oil preparations is the most largely produced in this country, and halibut liver oil are the best supplementary sources of this vitamin.

THE VITAMIN B COMPLEX

In the first volume of the *Lancet* of 1906 there is an article on "The Preservation of the health of the personnel of the Japanese Navy and Army," written by Takaki, Director of the Medical Department of the Japanese Navy. Having, as a young naval officer, noted the curse of beri-beri in the naval service, he came to St. Thomas' Hospital, London, in 1875 to enlarge his knowledge of medicine and to note conditions in European navies where beri-beri was unknown. Beri-beri, a disease marked by muscular wasting and paralysis of the legs, is very prevalent in China and India, and is not unknown in Norway and Newfoundland. Believing that he was faced with a dietary deficiency and not an infectious disease, Takaki was

of two training ships. The first vessel sailed from Japan to New Zealand, South America and Honolulu making the voyage in 272 days. There were 169 cases of beri-beri and 25 deaths

deficiency. This opinion, however, is not supported by Sinclair and his co-workers of the Oxford Nutrition Survey. The black-out conditions obtaining during the war have been ideal for detecting clinical abnormalities in dark adaptation, yet from centres so far apart as Aberdeen and Chicago the statement is forthcoming that "a deficiency of this vitamin is not common". Recent work by Sir Edward Mellanby has shown that a deficiency of vitamin A may result in a reduction of osteoclastic activity whereby the normal process of removal of bone from the internal surfaces of the skull and spinal canal is restricted, producing pressure symptoms associated with the function of the cranial nerves (Mellanby, 1947).

Sources of Vitamin A.—Vitamin A is found in fats of animal origin—milk, cream, butter, egg-yolk and liver. The most important source is fish liver oil, because the organism stores most of the excess of vitamin A in the liver. It is not found in vegetable oils, e.g. linseed oil, olive oil. Fish either derive their vitamin A from marine algæ or make it themselves: the latter theory is the more probable, since fish and mammals form their own type of vitamin A from ingested precursors of the vitamin. Vegetable leaves which turn green are good sources of the vitamin; green vegetables and carrots do not contain vitamin A but its precursor carotene.

Vitamin A is readily oxidized and becomes inert; in fat, *especially if rancid, it slowly becomes inactive but in certain* oils, e.g. wheat-germ oil, it is protected by anti-oxidants.

The vitamin A content of foods is expressed in international units (i.u.). One international unit of vitamin A = 0.6 μg. (micrograms) or 0.0006 mg. of beta-carotene which is equivalent in activity to 0.34 μg. of vitamin A acetate. Children and pregnant women require relatively more vitamin A than adults. According to accepted standards an adult should receive 8000 i.u. daily; a child of 1 year 1200 i.u., adolescents 4000 to 5000 i.u. During the latter half of pregnancy and lactation the requirement is 4000 and 6000 i.u. per day respectively. From the results of recent dietary surveys, these figures should be regarded as optimal. It may be safe to say that a diet could be regarded as adequate if it supplied 60 i.u. of vitamin A per kg. of body weight daily for adults, and 80 i.u. per kg. of body weight for nursing mothers. These doses are maximal because the source of vitamin A is carotene and in the diet two-thirds of

in a crew of 276 men. The second vessel repeated the same journey taking 287 days. There were 14 cases of beri-beri and no deaths. The change in diet amounted to an increase in rice of 5 oz., vegetables 3 oz., meat 2 oz. and an unspecified amount of condensed milk. Subsequently, and with very excellent results, a new dietary was introduced into the Japanese Navy; rice was decreased, vegetables increased, wheat and bread and 1¼ pints of milk daily were added. In 1897 Eijkman, a Dutch physician, had demonstrated on men and fowls that beri-beri, as also its equivalent in fowls, was a dietary deficiency disease and capable of cure by simply adding rice polishings to the diet. Numerous experiments by British and American army medical officers in the East further proved that beri-beri could be prevented by having unpolished rice or a sufficiency of beans in the diet. Reference will be made later to the part played by beri-beri amongst British troops during the siege of Kut-el-Amara in 1917.

The first idea that a water soluble food factor, present in milk and certain vegetables, may be responsible for the restoration of growth following the steady decline produced by a diet of purified proteins, carbohydrates, fats and mineral salts came from Sir Frederick Gowland Hopkins of Cambridge. The name "water soluble B" was given by McCollum in 1915 and was used by him to designate a single factor which could induce growth and cure polyneuritis in pigeons. In 1911 Funk crystallized a substance which, thinking he was dealing with an "amine structure", he called the "beri-beri vitamine". As a result of much laborious research vitamin B_1 was isolated and ultimately structurally identified and synthesized by Williams and Cline in 1936. With the synthesis completed, vitamin B_1 became known in this country as aneurin and in U.S.A. as thiamine. For many years previously, it had been known that what was called vitamin B consisted of two factors, one named B_1, an anti-neuritic factor, the other, B_2, a growth-promoting factor, and that neither was much affected by ordinary cooking processes.

THIAMINE (Aneurin, Vitamin B_1)

One of the first signs of vitamin B_1 deficiency is involvement of the nervous system. Many cases of neuritis in man have

been cured by giving very small doses (10 mg.) of thiamine daily. The dramatic recovery from polyneuritis in birds following the addition of vitamin B_1 to the diet is shown in Figs. 27 and 28. Some extremely illuminating experiments have been performed by Professor Peters of Oxford. He it was who discovered that pigeons dying of polyneuritis had an increased amount of lactic acid in the brain, due to a failure to complete the oxidation of glucose. When thiamine was injected into these pigeons the lactic acid disappeared, proving that it was of importance in regulating the metabolism of carbohydrate. Another product

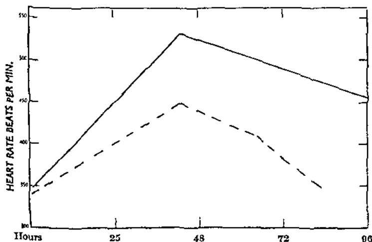


FIG 29.—Effect of whole bread (vitamin B_1), and white on the heart rate (*Birch and Harris*)

of incomplete combustion of carbohydrate which accumulates in the blood of an animal suffering from a thiamine deficiency, is pyruvic acid. This causes a marked slowing in the frequency of the heart beat: in the rat it may be reduced from a normal frequency of 500 to 300 beats per minute So dramatically is the normal frequency of beat restored by finely graduated doses of thiamine that Harris, who is responsible for these facts, has used this as a test for the vitamin B_1 content of foods. In Fig. 29 is shown graphically the response of the slowed heart beat to white and whole grain bread, the latter being comparatively rich in vitamin B_1. The activity of the vitamin is also associated with the maintenance of tone in muscle, particularly



Fig. 27 —Polyneuritis in Birds A The characteristic attitude of a pigeon with polyneuritis (avian beri-beri) after three weeks' feeding with polished rice. This extreme effect passed off within three hours after feeding vitamin B containing foods



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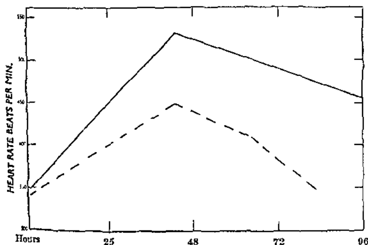


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FIG 27.—Polyneuritis in Birds. A. The characteristic attitude of a pigeon with polyneuritis (avian beri-beri) after three weeks' feeding with polished rice This extreme effect passed off within three hours after feeding vitamin B containing foods.



FIG. 28.—The same pigeon three hours after feeding vitamin B rich foods (whole cereals and yeast) Twelve hours later it would have been impossible to pick this bird from other healthy birds [From Morse's *Applied Biochemistry*.]

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logical need, but, as far as nutritional requirements are concerned, only a secondary physiological need.

But is the "instinct" which determines selection of the correct food dependent upon the presence of vitamin B? It is well known how too much sugar in a dietary, or in children how too great a consumption of sweets and chocolate, will destroy the appetite, particularly the appetite which craves for wholesome food. A decrease in sugar tolerance, an increase in lactic and pyruvic acids in the blood and tissues, an impairment of appetite and a marked diminution of the activity of the intestine are all associated with vitamin B_1 deficiency. No one in such a bad physiological condition has ever been noted for his ability or even desire to practise any method of dietary selection. Gastro-intestinal disorders have increased with the departure from primitive food habits. The modern affliction, constipation, with most of its attendant ills, has been experimentally produced in animals and man and experimentally relieved, if not entirely cured, by adding to the diet those foods or foodstuffs which contain large amounts of thiamine namely, wheat germ, whole grains, yeast extract, brewer's yeast concentrate, or by giving pure thiamine. These facts simply confirm the statement first made by Sir Robert McCarrison, I.M.S., that "deficiency of vitamin B_1 was responsible for many of the more common disturbances of the gastro-intestinal tract"

A deprivation of this important food factor will cause a retardation in the growth of infants and young children. The failure to grow is, as may be imagined, coupled with loss of appetite and vigour. Numerous experiments with children have proved the value of thiamine. As an example of the type of experiment performed, mention may be made of one carried out on two groups of undernourished children, 11 to 13 years of age; one group was given, at the school lunch, two rolls made of white flour, the other, two rolls made of flour containing equal parts of white flour and wheat germ. The average [illegible]

for the wheat germ group it was 95½ lb.

With regard to the part played by vitamin B_1 in reproduction and lactation, the most striking comment comes from the East, namely, that women who have suffered severely from

the plain muscle of the stomach and intestine. It will be readily realized that upon a normal tone of muscle depends that undefinable sense of well-being, which is often reflected in a good appetite. To what extent and in what manner thiamine, or any of the vitamins of the B complex, is related to these physiological and psychological events, it is still difficult to say. It has been said that "rats deprived of vitamin B possess no instinct which prompts them to select food containing this vitamin when a variety of foods is offered them". In the human sphere this would mean that we have no instinctive liking for the right kind of food. In contrast to this, however, must be placed the results of experiments by Professor Richter of Johns Hopkins University School, in which rats, amply provided with purified protein, fat and carbohydrate, and with an array of 20 tubes containing in solution the essential mineral salts and vitamins, selected a diet perfectly suited to their needs. When the suprarenal glands, regulating salt metabolism, the pancreas, responsible for the digestion of protein, fats and carbohydrates and also, by insulin production, for the metabolism of carbohydrate, and the parathyroids, regulators of calcium metabolism were individually removed, the rats quickly adjusted their selection of the proffered foods to meet, as far as was possible, the new demands occasioned by the changes rather drastically thrust upon them. Richter has also shown that when given the [illegible] free self-selective [illegible] riboflavin and [illegible]

Tribe and Wilson (1949) designed experiments to determine whether, when given a free choice between two compound diets, both deficient in vitamin B complex, rats would select that diet on which they could synthesize the required vitamins by refection. The diets were identical except for the starch contents; one consisted of unground maize starch, the other of unground potato starch. The former does not permit refection while the latter does, owing to its lower solubility. All the animals prefered to eat the former and therefore developed avitaminosis and died. The reason for this is that the rats preferred maize starch because it did not occasion the untoward effects of indigestion produced by potato starch. It is possible, therefore, that their appetites were determined by what was, as far as pain or discomfort is concerned, a primary physio-

or any nutrient, which will permit a predetermined amount of work to be done without any sign of deterioration in its performance, rigidly standardized tests must be employed. These tests are influenced by such factors as pre-test activity, sleep, food, emotional states, temperature and relative humidity. The simplest of the tests applied are the bicycle, stepping, and the treadmill. The treadmill is the easiest to standardize, the bicycle and the stepping tests are more convenient to use and give reliable results.

Sources of Thiamine.—Foodstuffs which are rich sources of this vitamin are: wheat germ, rice germ, egg-yolk, yeast, ox liver and the pulses, i.e. beans, lentils, peas, soya bean. With regard to the cereals an interesting differentiation has been established between the constituents of the grain. The largest deposit of this vitamin is in the germ (i e. the embryo and scutellum); the bran (i.e. the pericarp and aleurone layer) and the endosperm contain very little. Figures 21 and 43 show these important points, and the effect of milling or polishing the grain will be at once evident. In the case of wheat and rice, the germ, weight for weight, is many times more potent than the bran in the cure of polyneuritis, indeed, the amount of thiamine in bran may be regarded as negligible. Hovis, a germ bread, is prepared from three parts of white flour and one part of wheat germ, and approximates wholemeal bread in its vitamin B_1 content. White flour contains relatively little vitamin B_1 compared with wholemeal flour. English whole flour, 100 per cent extraction contains 294 micrograms of vitamin B_1 per 100 grams; 85 per cent extraction, 258 micrograms; 70 per cent extraction, 87 micrograms per 100 grams of flour. This means that in milling English wheat to 70 per cent extraction 71 per cent of vitamin B_1 is lost.

The pulses—peas, beans, lentils—are valuable sources of vitamin B_1 as are meat offals—heart, kidney, liver—and bacon, pork and eggs. Milk should not be regarded as a good source; beef and white bread are lacking in it. While spinach and carrots contain the vitamin they are not to be commended as good sources of supply. These facts were of importance before 1939, when many people in this country lived on meat, sugar, bread and highly refined cereals. Professor Cathcart and Dr. Murray of Glasgow, showed, many years ago, that many working men and women who were consuming over 3000 Calories

beri-beri rarely, if ever, have children. Where, as in the Orient, vitamin B_1 deficiency is so common, it is not surprising to find a high infant mortality and high incidence of disease and physical unfitness amongst children and adolescents. Where dietary deficiencies are prevalent, there one often finds the vicious circle of early marriage and poor physical and mental development. Under conditions of a markedly restricted supply of thiamine, all glandular organs—thyroid, pituitary, suprarenals, ovaries, etc.—are under-developed, their hormones *and their physiological activities are short-lived.* Well may the question arise as to whether or not those social customs, associated with the reproduction of the species, are determined by the time of optimal development of reproductive hormones, which, in the final analysis, is dependent upon an adequate supply of essential vitamins. Where thiamine is deficient in the diet of the mother, the child may show signs of beri-beri and may die of paralysis, convulsions or heart failure.

In determining the thiamine content of foods, several methods have been used. The first were biological; the rat, having little store of thiamine, fed on a standard thiamine deficient diet was soon depleted of its vitamin, as shown by the cessation of growth. It was then fed that amount of thiamine which would induce growth at the rate of 3 grams per week for a period of 6 to 8 weeks. With the synthetic preparation of thiamine the method becomes simpler and more accurate. A known amount of thiamine is fed to a group of rats while known amounts of the foodstuff are fed to other groups. That amount of foodstuff, which, when fed to the group, gives a growth curve parallel to that of the known amount of thiamine, contains the amount experimentally administered.

Interesting as a recent development is the use of microbiological methods, based upon the fact that thiamine is essential for the growth of several organisms

Most important among all facts concerning the bodily requirements of thiamine is that the amount is strictly related to energy needs. During the war millions of men and women were recruited and examined as to their physiological and psychological fitness. To determine a man or woman's fitness for the performance of industrial or military duties, it is necessary to examine the effect of environment, nutrition and fatigue upon performance. In assessing the amount of thiamine



Fig 30 — A case of ariboflavinosis showing seborrheic excrescences on the forehead, nose, cheeks, lips and chin and around the naso-labial folds

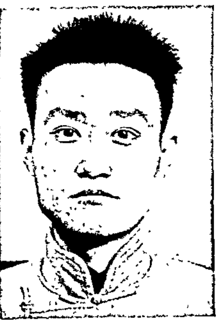


Fig 31 — The same case after treatment with riboflavin 15 mg, first two days, 10 mg for the next two days and 5 mg daily for one week

[By courtesy of the late Dr Bernard Read and Dr. H C. Hou, Shanghai, and Messrs. Wm Heinemann, Ltd]

[To face page 170

per day, derived 64 per cent of their energy from these foods which are poor sources of, or entirely lack, vitamin B_1.

The international unit of vitamin B_1 has been defined as 3 μg. of thiamine hydrochloride. As a result of many experimental tests, it may be accepted that 0·5 milligram or 166 i.u. of thiamine hydrochloride per 1000 Calories is an adequate amount for an adult. The recommended allowance of the National Research Council, U.S.A., is slightly higher than this. The nursing mother requires most, and it would be safe to say that for her the diet should supply at least 2·0 mg. per day.

TABLE 37

THIAMINE (ANEURIN. VITAMIN B_1) FOODS—EDIBLE PORTION

mg. per 100 g.

Wheat (germ) . .	2·5 to 5·0	Eggs . . .	0·1 to 0·15
Flour, wholemeal .	0·35 to 0·4	Beef and mutton .	0·05 to 0·1
85 per cent extraction		Pork . . .	0·55 to 0·7
(National) . .	0·30 to 0·4	Fish . .	0·02 to 0·06
70 per cent extraction		Fruits . . .	0·02 to 0·05
(white) .	0·05	Fresh vegetables .	0·02 to 0·1
Oatmeal .	0·5	Green peas . .	0·17
Yeast . .	1·8 to 3·0	Pulses . . .	0·5 to 0·9
Milk .	0·04 to 0·06		

RIBOFLAVIN (B_2 : G)

In 1927 Sherman and his co-workers had experimentally proved that there was another growth promoting vitamin which did not cure polyneuritis. This vitamin, found in autoclaved or heated yeast, was recognized as the pigment to which the greenish colour of whey is due and accordingly it received the name lactoflavin. It was found to be present in milk in conjunction with carotene the precursor of vitamin A. The complexity of the new vitamin was revealed by the studies of Warburg and Christian (Berlin, 1932), who isolated from yeast a "yellow oxidative enzyme", or yellow respiration ferment, which plays a part in all cellular respiration. Later it was shown that this enzyme was found to consist of a combination of protein, phosphoric acid and lactoflavin. When chemists had determined the structure of the vitamin or pigment, they renamed it riboflavin, because of the nature of the sugar (ribose) which formed a part of it. The alphabetic terminology, B_2 and



Fig. 33. The feet of the same patient. Before treatment the skin is highly pigmented and glossy. After treatment the skin has been almost restored to its normal condition. [*From Dr S. L. Simpson, the London Hospital, by courtesy of Messrs. Wm. Heinemann, Ltd.*]

[*To face p.* 32



FIG. 32.—A case of pellagra in the London Hospital under Dr. S. L. Simpson. Arm on the left before treatment shows pigmentation and thickening of the skin, which is cracked and glossy. After two weeks' treatment with vitamin B complex but without aneurin (vitamin B_1) the skin is practically normal. [*From Dr. S. L. Simpson, the London Hospital, by courtesy of Messrs. Wm. Heinemann, Ltd.*]

[*At page 177 to face Fig. 33.*

G, has been discarded: the name riboflavin was officially decided upon by the Council on Pharmacy and Chemistry of the American Medical Association in 1937.

The principal activities of riboflavin are to promote growth and to maintain a healthy condition of the skin in man and the coat in animals. Dr. Sydenstricker has described the clinical condition following riboflavin deficiency, namely a cracking of the skin at the corners of the mouth, glossitis—a smooth condition of the tongue—a dermatitis around the folds of the nostrils, all of which respond promptly to treatment with riboflavin, or foods rich in it (Figs. 80 and 31).

TABLE 38

RIBOFLAVIN-FOODS—EDIBLE PORTION

mg per 100 *g.*

Yeast	5 0	Egg—fresh	0 4
Wheat	0 06 to 0 20	,, dried	1 3
Barley	0 12 to 0 35	Meat	0 25
Pulses	0 15 to 0 3	Liver	3 0
Milk—whole	0 15 to 0 20	Fruit	0 03
" powder	1 15 to 1 60	Vegetables	0 05
Cheese	0 50	Pulses (dried)	0 3

Sydenstricker and his associates have also described the effects of riboflavin deficiency upon the eyes—photophobia, burning of the eyes, corneal ulcers, corneal vascularity, dimness of vision. Sebrell and Butler (1938) gave a full description of the experimental deficiency of riboflavin in man; the syndrome, called ariboflavinosis, involves the eyes and skin, specially junctions between skin and mucous membrane; the skin is rough, scaly and greasy, the lips bright red, swollen and cracked, the tongue large and tender and magenta in colour. The response to specific treatment is most satisfactory It may be mentioned that no satisfactory response was obtained when the patients were given vitamin A, thiamine, ascorbic acid or nicotinic acid

Sources of Riboflavin.—Many of the foods which contain thiamine are fortunately rich in riboflavin: the exception is egg-white which contains no thiamine. The best source is brewer's yeast, followed closely by liver and kidney. Egg-yolk, milk and cheese are also good sources as are also the green leafy vegetables and beans. It is also found in germinating seeds.

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some 200 mg. of tryptophan to secure a similar result (Leucke *et al.*, 1947). The original idea that pellagra was due to some toxic material in maize began to lose favour when it was [illegible]

theory and the tryptophan deficiency suggestion were ruled out by the discovery of Goldberger (1925) and his fellow-workers that pellagra could be cured by a protein-free extract of ox liver, and the final separation and crystallization of the nicotinamide by Elvehjem, Madden, Strong and Wolley (1938).

TABLE 39

NICOTINIC ACID IN FOODS

mg. per 100 *g*

Yeast, dry	10 to 50	Kidney	6 to 10
Wheat, whole	2 8 to 5 0	Fresh meat	3 to 10
Flour, white	0 6 to 0 8	Cow's milk	0
85 per cent extraction (National)	1 5 to 2 0	Bread—whole grain	5 0
		,, white	1
Bran	30 to 35	Fish	3 to 8
Liver, fresh	10 to 27		

Clinical studies in pellagra show that nicotinic acid is essential for the normal activity of the alimentary tract, the skin and the nervous system It has been suggested that nicotinic acid may play some part in regulating the carbohydrate metabolism of the brain (Himwich, Spies *et al.*, 1940). This may ultimately afford an explanation of the mental symptoms which are seen in cases of pellagra; these are restlessness, irritability, depression and apprehension, which may lead to marked emotional disturbances and an entire breakdown in personality. One can see in the progression of signs and symptoms which characterize developing pellagra, the whole gamut of changes which lead to the breakdown of individual morale. Perhaps nowhere so much as in the study of vitamin B complex deficiencies, does one become so fully aware of the part played by food in the maintenance of national morale.

Our knowledge of the human requirements of nicotinic acid is incomplete; it is suggested that the daily requirement is about 10 to 15 mg Dietary surveys in rural and mining areas in U.S.A. have clearly shown that where, as in rural areas, an adequate amount of eggs and milk was consumed, no pellagra

The daily requirement of riboflavin is, in milligrams, 50 per cent greater than that for thiamine, i.e. about 2 to 3 mg. per day.

NICOTINIC ACID (Niacin : P.P. Factor)

About the middle of the eighteenth century a disease was described under the name, "mal de la rosa", as being prevalent in Italy, Roumania, and other Southern European countries. In the early years of the twentieth century it caused some concern in the United States and under the name "Pellagra" was described as a disease affecting the alimentary tract, the skin and the nervous system. The skin lesions are typical, being confined to the dorsal surfaces of the hands and feet, the forearms and legs, and the face and neck, where the skin finally becomes dry, thickened and of a dark red colour (Figs. 32 and 33). Symptoms associated with the nervous system range from lassitude and irritability to profound depression and ultimately dementia. It is a poor man's disease and in the United States of America is definitely related to the cotton areas of the South. The fact that the diet of those most commonly affected was composed of cornmeal, white flour, sugar, molasses and polished rice, led Goldberger in 1919 to carry out a nutritional experiment on twelve men who voluntarily subsisted on the diet mentioned, and of whom six developed definite signs and symptoms of pellagra. It was subsequently discovered that autoclaved yeast, that is yeast with no thiamine, contained a substance which would prevent pellagra. To this substance was given the name "P.P. factor" (pellagra-preventing factor). Since riboflavin is present in heated yeast, it had to be eliminated as the curative factor in pellagra. It was soon demonstrated that riboflavin had no influence upon the course of the disease. In 1937 Elvehjem found that nicotinic acid, or its amide, would cure pellagra in two to three days, even when the patient showed signs of marked mental derangement.

In the same year Elvehjem isolated in crystalline form 175 mg. of nicotinic acid amide from 10 kg. of fresh liver. Comparatively recent studies have indicated a relation between nicotinic acid and tryptophan in nutrition ; it has been shown that where a deficiency of nicotinic acid can be corrected by administering 10 mg. of nicotinic acid daily to pigs, it requires

and man. Folic acid is a term covering a group of chemically distinct substances, the simplest of which is pteroylglutamic acid. Either as a liver concentrate or as folic acid *per se*, it cures the anæmia and leucopenia (lack of white blood-cells) often caused by the administration of sulphonamides. For a further discussion of the action of folic acid see page 151

Vitamin B_{12}.—This substance, extracted from the liver, contains a small amount of cobalt and is effective in curing both the hæmatological and neurological manifestations of pernicious anæmia. As a result of much recent work in the field of vitamin B_{12} research, two further members of this group of B factors have been crystallized,—$B_{12}c$ and $B_{12}d$—(Anlow *et al.*, 1950); $B_{12}a$ and $B_{12}b$ are reduction products of B_{12}, (Brockman *et al.*, 1950). It would appear that Castle's extrinsic factor is vitamin B_{12}, (Lester Smith, 1951). Further research is still required before a complete theory of the mode of action of vitamin B_{12} is possible. Vitamins $B_{12}c$ and $B_{12}d$ do appear to effect a definite clinical and hæmtological improvement in cases of pernicious anæmia (Ungley and Campbell, 1951; Chalmers, 1951).

Vitamin Synthesis.—The vitamins of the B group still afford an ever expanding field for research which holds for many a speculative interest. Thiamine, riboflavin and nicotinic acid are clearly associated with well-defined deficiency diseases. There are however other factors which are of scientific interest, but whose functions are too problematical for any detailed consideration here. Pantothenic acid, biotin, folic acid and *p*-aminobenzoic acid are synthesized by the intestinal flora of animals, and if this can be proved to be true for man, it may explain the fact that none of these factors is associated with a dietary deficiency disease. Pantothenic acid and biotin are also known to be responsible for the growth of micro-organisms. Para-aminobenzoic acid exerts an important biological action in that it counteracts the anti-bacterial effects of the sulphanilamides. Other interesting members of the vitamin B_2 complex are inositol, choline and methionine. Inositol, the basic structure of the phytic acid, occurs in heart muscle, kidney and yeast; its absence causes a loss of hair in the rat; choline prevents the development of fatty liver in depancreatized dogs and methionine is one of the essential amino-acids. There is evidence that vitamin B_1 (Najjar and Holt, 1943), riboflavin

was seen, while in mining areas, deficient in these articles of diet, pellagra was often endemic.

The name "Niacin", accepted by the United States Food and Drug Administration, was coined by Dr. Cowgill of Yale University, from "ni" for nicotine, "ac" for acid and "in" for vitamin. The name was suggested in order that a nutrient should not, by terminology, have association with the nicotine of tobacco. Although related to the nicotine of tobacco, it has not, of course, its toxic properties. The name nicotinic acid is, however, used in scientific circles. One of the most stable of the B complex vitamins, nicotinic acid is resistant to heat, light, oxidation and alkalis.

Sources of Nicotinic Acid.—Foods which are rich in the vitamin are: yeast, liver and peanuts. Meat contains small [illegible] in [illegible] es [illegible] .)

Other Members of the B Complex.—Four members of the B complex group, different in chemical and physical properties but not in their action in determining the texture of the skin and the pigmentation of the hair, are pyridoxine, pantothenic acid, biotin and *p*-aminobenzoic acid. They are found in animal and vegetable foods such as yeast, liver, kidney and *the outer coats of grains. Biotin is the only one which has any* definite rôle in human nutrition; it was isolated from egg-yolk and has been shown to be essential for the growth of many micro-organisms, moulds and yeasts. It has long been known that uncooked egg-white in high concentration can be toxic to rats; this is due to the failure of biotin, the protective factor guarding against egg-white injury, to form a stable compound with avidin, a protein of egg-white. The compound, when formed in the intestine, is not hydrolyzed and therefore not absorbed. The essential cause of egg-white injury is a biotin deficiency which, in the rat, is characterized by loss of weight, spastic paralysis and dermatitis. Experiments have been carried out on man in whom a biotin deficiency had been produced by eating large amounts of raw eggs or dried egg-white. The loss of hair and the dermatitis were quickly cured by injections of biotin methyl ester.

Folic Acid.—This is the vitamin essential for the growth of chicks and important as an anti-anæmia factor in monkeys

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(Najjar *et al.*, 1944), and nicotinic acid (Ellinger *et al.*, 1944) can be synthesized in the human alimentary tract. The action of milk in preventing pellagra and maize in producing it, may depend on the effect of these foods on the intestinal flora. One of the startling although not recent discoveries in the vitamin field is the fact that rats could grow and thrive without vitamin B_1 in their food. This ability to grow in the absence of exogeneous vitamin B_1 could only be possible if the vitamin were obtained endogenously, that is by synthesis within the alimentary tract. When Eijkman (1897) first discovered that polyneuritis was produced in fowls by feeding them polished rice, he also noted that if potato starch were added to the diet they failed to develop this disease. Kon and his co-workers have now brought forward evidence to show that in the presence of potato starch intestinal bacteria do manufacture vitamin B_1. This ability to synthesize vitamin B_1 is called "refection", meaning to refresh or make again. Refection is no recent discovery (Fridericia, 1926); its chemical explanation, in terms of bacteria and vitamins, has been the subject of much work during the past fifteen years. These discoveries tend to cast doubt on the generally accepted requirements for various vitamins. The study is however in its early stages and "one would do well to guard against going to the other extreme and placing too much reliance on possibilities of symbiotic self sufficiency of man" (Kon, 1945).

In view of the public interest in the use of synthetic individual vitamins, a word of caution may be necessary. It is becoming increasingly clear that, instead of supplying any one vitamin from the B group, in the treatment of any specific B avitaminosis, it is better to provide all the members of the group. Dr. Marion Richards of the Rowett Research Institute has recently suggested that "improvements effected in poor human diets by means of such simple supplements as inorganic calcium, milk and dried yeast, provide a useful pointer for the post-war feeding of starved populations". Her work emphasizes the need for caution in any attempt to improve diets by the indiscriminate addition of large supplements of single synthetic B vitamins. Insufficient knowledge of the many interrelated reactions of vitamins demands caution in the therapeutic use of synthetic vitamins and emphasizes the value of a mixed diet supplying all accessory food factors in their natural state.

tendons under the ham rigid, a symptom none of the rest had were put under a course of sea water. Of this they drank half a pint every day, and sometimes more or less as it operated as a gentle physic. Two others each had two oranges and one lemon given them every day. These they ate with greediness, at different times upon an empty stomach. They continued but six days on this course, they having consumed the quantity that could be spared. The two remaining patients took the bigness of a nutmeg three times a day of an electary recommended by an hospital surgeon, made of garlic, mustard seed, balsam of Peru, and gum myrrh, using for common drink, barley water well acidulated with tamarinds, by a decoction of which with the addition of *cremor-tartar* they were gently purged three or four times during the course.

"The consequence was that the most sudden and visible good effects were perceived from the use of the oranges and lemons; one of those who had taken them being at the end of six days fit for duty. The spots were indeed not quite off his body, nor his gums sound; but without any other medicine than a gargarism of 'elixir vitriol', he became quite healthy before we came to Plymouth, which was on 16th June. The other was the best recovered of any in his condition; and being now deemed pretty well, was appointed nurse to the rest of the sick.

"Next to the oranges I thought the cyder had the best effects. It was indeed not very sound being inclinable to be aigre or pricked. However, those who had taken it were in a fairer way of recovery than the others at the end of the fortnight, which was the length of the time all these courses were continued, except the oranges The putrefaction of their gums, but especially their lassitude and weakness, were somewhat abated and their appetite increased by it.

"There was no remarkable alteration upon those who took the electary and tamarind decoction, the sea water or the vinegar, on comparing their condition with others who had taken nothing but a little lenitive electary and *cremor-tartar*, in order to keep the belly open; or a gentle pectoral in the evening for relief of their breast" (Lind, 1757).

As a result of these experiments, Lind recommended that lemon juice be given at regular intervals to all sailors on British naval vessels when at sea.

CHAPTER XI

VITAMINS AND DIETARY DEFICIENCY DISEASES (*contd.*)

VITAMINS C, D, E and K

ASCORBIC ACID or VITAMIN C

This is the antiscorbutic vitamin. Scurvy has for centuries been regarded as a disease due to dietetic errors, and rightly so. Amongst sea-faring folk, scurvy has been known to occur after deprivation for long periods of fresh foodstuffs, and it was common knowledge that it could be prevented or rapidly cured when fresh vegetables or fruits were available. The disease was long thought to be due to the effects of northern sea climate and the use of salt meat. The ships of the British Naval and Maritime Services were the scene of many an experiment carried out on the unfortunate human material which circumstances so liberally provided. Two instances may be quoted from the Medical Research Council's Report on "Vitamins" (1932), which show how surgeons and others in the Navy were constantly attempting to find out the cause of this disease so dreaded by seamen and explorers. In the year 1747 the surgeon of H.M.S. *Salisbury* wrote: "On the 20th of May, 1747, I took 12 men in the scurvy on board the *Salisbury* at sea. They all had putrid gums, the spots, and lassitude with weakness of their knees. They all lay in a proper apartment for the sick in the forehold and had one diet common to all, viz. water gruel sweetened with sugar in the morning, fresh mutton broth oftentimes for dinner; at other times light puddings; boiled biscuit with sugar, and for supper barley and raisins, rice and currants, sago and wine or the like. Two of these were ordered each a quart of cyder a day. Two others took twenty-five drops of 'elixir vitriol' three times a day, upon an empty stomach; using a gargle strongly acidulated with it for their mouths. Two others took two spoonfulls of vinegar three times a day upon an empty stomach; having their gruels and other foods well acidulated with it, as also the gargle for their mouths. Two of the worst patients, with the

tendons under the ham rigid, a symptom none of the rest had were put under a course of sea water. Of this they drank half a pint every day, and sometimes more or less as it operated as a gentle physic. Two others each had two oranges and one lemon given them every day. These they ate with greediness, at different times upon an empty stomach. They continued but six days on this course, they having consumed the quantity that could be spared. The two remaining patients took the bigness of a nutmeg three times a day of an electary recommended by an hospital surgeon, made of garlic, mustard seed, balsam of Peru, and gum myrrh, using for common drink, barley water well acidulated with tamarinds; by a decoction of which with the addition of *cremor-tartar* they were gently purged three or four times during the course.

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CHAPTER XI

VITAMINS AND DIETARY DEFICIENCY DISEASES (*contd.*)

VITAMINS C, D, E and K

ASCORBIC ACID or VITAMIN C

THIS is the antiscorbutic vitamin. Scurvy has for centuries been regarded as a disease due to dietetic errors, and rightly so. Amongst sea-faring folk, scurvy has been known to occur after deprivation for long periods of fresh foodstuffs, and it was common knowledge that it could be prevented or rapidly cured when fresh vegetables or fruits were available. The disease was long thought to be due to the effects of northern sea climate and the use of salt meat. The ships of the British Naval and Maritime Services were the scene of many an experiment carried out on the unfortunate human material which circumstances so liberally provided. Two instances may be quoted from the Medical Research Council's Report on "Vitamins" (1932), which show how surgeons and others in the Navy were constantly attempting to find out the cause of this disease so dreaded by seamen and explorers. In the year 1747 the surgeon of H.M.S. *Salisbury* wrote: "On the 20th of May, 1747, I took 12 men in the scurvy on board the *Salisbury* at sea. They all had putrid gums, the spots, and lassitude with weakness of their knees. They all lay in a proper apartment for the sick in the forehold and had one diet common to all, viz. water gruel sweetened with sugar in the morning, fresh mutton broth oftentimes for dinner; at other times light puddings; boiled biscuit with sugar, and for supper barley and raisins, rice and currants, sago and wine or the like. Two of these were ordered each a quart of cyder a day. Two others took twenty-five drops of 'elixir vitriol' three times a day, upon an empty stomach; using a gargle strongly acidulated with it for their mouths. Two others took two spoonfulls of vinegar three times a day upon an empty stomach; having their gruels and other foods well acidulated with it, as also the gargle for their mouths. Two of the worst patients, with the

C, the blood fails to pass through these small vessels at the normal rate of flow. There results, therefore, stagnation of the

blood. Research workers in Sweden have noted that at the end of the winter season many people show the effect of a low-grade shortage of vitamin C. One of the tests applied to detect this is to measure the capillary pressure in the skin. At the end of the long Swedish winter, the capillaries of the skin of the arm in 10 to 25 per cent of the people examined show inability to withstand increased pressure from within. Gothlin has made this interesting observation in describing the effect of vitamin C medication in a 12-year-old country girl: "I shall never forget how this little girl with the dull, tired, resigned expression of face, through five weeks of intensive treatment with orange juice awakened, so to speak, how her movements became livelier and her eyes grew bright, and how her looks showed what pleasure she got out of life." This story can be repeated not only over the whole of Europe, but on the American continent and in India. The activity of vitamin C is essentially associated with the formation of intercellular substance whereby tissue cells are held together in correct relation to each other, thus permitting them to function properly. In the old days at sea, persistent boils, open wounds, bleeding gums and weak ligaments were common. The part played by vitamin C in wound healing is well described by Crandon who subjected himself to wounds made on his back under normal conditions and also, after six months on a vitamin C deficient diet, when signs of scurvy had appeared. The results were corroborative of the work of many investigators. Briefly, it was shown that, after six months on a deficient diet, a wound would heal apparently satisfactorily but, when examined on the tenth day, it was found that beneath the skin there was no healing and the wound was filled with blood clot. The wound had to be opened and drained and the subject was given 1000 mg. of vitamin C by intramuscular injection. Ten days later, examination showed excellent healing. Wounds break down because of the absence of the intercellular substance—collagen—and the injection of vitamin C will prevent wound disruption from this cause. There are, of course, other causes of delayed healing of wounds and

A most notable observation was made by Charles Curtis, surgeon of the frigate *Edinburgh*, in 1807. Writing about the treatment of scurvy, he states: "With regard to sea scurvy reports and accounts have been published as if this had been cured at sea by lime or citron juice, lemon rob, and nitre dissolved in vinegar. *But there is a plan for the cure of this disease* which depends upon a fresh vegetable diet, greens or roots in sufficient quantity. To be sure we cannot have a kitchen garden at sea and a short and scanty crop of green can only be raised on board ship, but beans and peas and barley and other seeds brought under the malting or vegetating process are converted *into a state of a growing plant, with vital principle* in full activity throughout the germ and pulp, and if eaten in this state without any sort of preparation, except that of separating or rejecting the husks, cannot fail to supply precisely what is wanted for the cure of scurvy, viz. fresh vegetable chyle."

Here is the heart of the problem; the essential substance is associated with *active metabolic processes.* The distribution of this factor (vitamin C) thus presents a marked contrast to that of the antiberi-beri vitamin B_1, which is found chiefly in dry seeds.

After many experiments on fruits, cereals and vegetables in which it was discovered that their antiscorbutic properties were destroyed by heating, the essential substance was extracted from orange juice by means of alcohol. The name, vitamin C, was given in 1920 by Sir Jack Drummond. The structural formula of vitamin C was determined in 1933 by the late Professor Sir Norman Haworth; he and Professor Szent-Gyorgyi of Hungary, proposed the name ascorbic acid, by which the vitamin is now known.

Effects of Vitamin C Deficiency.—In scurvy the first symptoms are tenderness and swelling of the joints; ultimately hæmorrhage of the soft spongy gums, and from the mucous membrane of the stomach and intestine supervenes. Some believe that gastric and duodenal ulcers may be associated with a deficiency of this vitamin. The changes in the structure of the bones and teeth in children can be seen by X-ray examination long before the naked eye signs are noticeable. This vitamin is responsible for the normal condition of the endothelial lining of the blood vessels, particularly the capillaries. As a result of the swelling of the endothelium, due to a deficiency of vitamin

C, the blood fails to pass through these small vessels at the normal rate of flow. There results, therefore, stagnation of the blood and a deficient oxygenation of the tissues from which proceed fatigue, breathlessness, debility and anæmia. In some cases the vessels rupture, giving rise to small extravasations of blood. Research workers in Sweden have noted that at the end of the winter season many people show the effect of a low-grade shortage of vitamin C. One of the tests applied to detect this is to measure the capillary pressure in the skin. At the end of the long Swedish winter, the capillaries of the skin of the arm in 10 to 25 per cent of the people examined show inability to withstand increased pressure from within. Göthlin has made this interesting observation in describing the effect of vitamin C medication in a 12-year-old country girl: "I shall never forget how this little girl with the dull, tired, resigned expression of face, through five weeks of intensive treatment with orange juice awakened, so to speak, how her movements became livelier and her eyes grew bright, and how her looks showed what pleasure she got out of life" This story can be repeated not only over the whole of Europe, but on the American continent and in India. The activity of vitamin C is essentially associated with the formation of intercellular substance whereby tissue cells are held together in correct relation to each other, thus permitting them to function properly In the old days at sea, persistent boils, open wounds, bleeding gums and weak ligaments were common. The part played by vitamin C in wound healing is well described by Crandon who subjected himself to wounds made on his back under normal conditions and also, after six months on a vitamin C deficient diet, when signs of scurvy had appeared. The results were corroborative of the work of many investigators. Briefly, it was shown that, after six months on a deficient diet, a wound would heal apparently satisfactorily but, when examined on the tenth day, it was found that beneath the skin there was no healing and the wound was filled with blood clot. The wound had to be opened and drained and the subject was given 1000 mg. of vitamin C by intramuscular injection. Ten days later, examination showed excellent healing Wounds break down because of the absence of the intercellular substance—collagen—and the injection of vitamin C will prevent wound disruption from this cause. There are, of course, other causes of delayed healing of wounds and

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kept at room temperature and with a small proportion of the oil of the rind in it. Heating to body temperature, 37°C., slowly destroys the vitamin. Oranges and lemons can be kept for months at 2–5° C. without the least detriment to the potency of their juice. Fresh meat is a source of the antiscorbutic vitamin, but it is not by any means a rich one. Milk is too variable to be relied on as a source of vitamin C.

When "lime juice" became the juice *par excellence* for the treatment of scurvy, the term was used to signify the juice obtained from Mediterranean lemons. The British Navy pinned its faith to "lime juice" until the middle of the 19th century. Owing to political reasons and to favourable reports on the acidity and antiscorbutic properties of the juice of the West India limes the supply of this juice was substituted for that from Mediterranean lemons. From 1804 until about 1860 lemon juice was the official issue. Scurvy had become a comparatively rare disease in the Navy. By 1850 very little, if any, lemon juice was in use in the Navy; the juice of the West Indian lime had taken its place. This change, while having apparently no great effect in the Navy, had disastrous results in that explorers, following the official lead, resorted to West Indian limes for their supplies of antiscorbutic foodstuffs. The most impressive example of the result of this change is that of the relief expeditions sent out in search of Sir John Franklin, first between the years 1847 and 1859, and then in the year 1875. Those ships which formed the first expedition were supplied with lemon juice, and enjoyed a remarkable immunity from scurvy for long periods of time. The second relief expedition which was sent out in 1875 was not strictly a relief expedition. It had two purposes: first, to find traces of Sir John Franklin; and second, to make an attempt to reach the North Pole. This Polar Expedition, as it was called, saw two ships, the *Alert* and *Discovery*, equipped with all the improvements that the experience of the previous 20 years had made possible, and with a liberal supply of *lime juice* of the best quality. The expedition was a failure largely because of scurvy in the crews of these ships, and the Admiralty Court of Enquiry in 1876 could come to no conclusion as to the cause of the tragedy. To-day Arctic and Antarctic expeditions take liberal supplies of concentrated lemon juice, e.g. the British Arctic Air Route Expedition to Greenland (H. G. Watkins, 1930–31)

there are parts of the body other than skin or muscle where a lack, or the presence, of intercellular substance may be responsible for normal physiological events, e.g. the release of the ovum from the ovary and its implantation in the uterus A lack of vitamin C in the diet leads to arrest of formation of enamel and cementum of the teeth (Fish and Harris, 1934). In the growth and repair of bone vitamin C plays an important part; ascorbic acid is important for the development of the protein matrix of bone as well as for the regular deposition of the bone salts, calcium and phosphorus. The changes in bone are similar to those which affect the formation of teeth; here in a case of deficiency the activity of the odontoblasts is diminished, the dentine is undeveloped and soft and the pulp of the tooth is disorganized. Despite much investigation there is no convincing proof that dental decay and disease of the gums are due to a deficiency of ascorbic acid.

Vitamins B and C have a distinct effect in helping to maintain the body's resistance to infection. This is, as has been pointed out, also a characteristic of vitamin A. Many cases of so-called rheumatic pains, which come and go and which are so common in this country, are doubtless due to a lack of vitamin C.

The part played by vitamin C in the development of strong teeth and healthy bones will be described in the chapter on dental caries.

Sources of Vitamin C.—The chief sources of this important vitamin are vegetables and citrous fruits. Of the leafy vegetables, the fresh green leaves of Brussels sprouts, cabbage, kale, parsley and watercress are excellent sources, while of the root vegetables, raw Swede turnips are useful. Potatoes because of the extent to which they appear in most dietaries are a valuable source of vitamin C. Carrots, lettuce, celery and onions are of little value. Peas and beans which have germinated have the vitamin, but if dry they are useless. It has long been known that oranges, lemons and grapes are the finest sources of vitamin C. As we shall see, much that is interesting in the history of the vitamin is associated with the use, or the failure to use, these fruits. Tomatoes, raw or cooked, are good, as are also bananas, apples, peaches, pineapples, raspberries and strawberries.

It is surprising to know that the juice of West India limes is distinctly inferior to that of oranges, lemons and of the sweet lime. Orange juice will retain its vitamins at high potency if

of Kut-el-Amara (December 1915–April 1916). In his account of the medical arrangements during the siege, Colonel Sir P. Hehir, I.M.S. (1917), wrote: "In an early stage of the siege, a recrudescence of beri-beri among British troops gave rise to some apprehension, but it then disappeared; whilst in Indian troops and followers during the latter half of the siege scurvy caused anxiety". At another place in this diary we learn that "the British troops were receiving white wheaten flour until 5th February 1916, after which date they were compelled to take part of their flour ration in the form either of barley flour or of atta. It is very significant that beri-beri should have occurred while the British troops were enjoying white wheaten bread and that it should have cleared up when they were compelled to share the coarsely milled, germ-containing flour of their Indian comrades." The incidence of scurvy during this siege showed an entirely opposite distribution. The British soldiers were protected by the large ration of meat, 8 to 20 oz., including horse flesh, which they consumed, while the Indian soldiers, largely vegetarian in habit, refusing meat on principle, suffered terribly from this disease.

The lesson to be learned from their experience is that germinating pulses contain vitamin C. Had the Indian dhal been moistened and allowed to germinate in the sun it would have contained the vitamin giving protection against scurvy. This possibility was discovered in 1916 by Dr. Harriette Chick, of the Lister Institute, London. Had these facts been known in 1915, one can well imagine that the fate of the garrison under General Sir Charles Townshend would have been different.

Human Requirements of Vitamin C.—Much controversy has centred around the adult requirement of vitamin C. It has generally been accepted that 50 mg. per day of ascorbic acid are sufficient. During the war, experiments on R.A.F. personnel certainly indicated a much lower requirement, namely 17 to 26 mg. per day. On these amounts thousands of young men have shown no signs of deficiency of this vitamin. Individual investigators have by tests on themselves and others corroborated the claim for a minimal value of 25 mg. per day. It would, therefore, appear that 50 mg of vitamin C per day is an optimal figure for a normal adult. A *nursing mother* should receive 100 mg. per day. Human milk contains approximately 6 mg. per 100 c.c.; if 600 c.c. of milk were secreted

It should be emphasized that dried vegetables are of no value for the prevention of scurvy since all their antiscorbutic properties have been destroyed in the drying.

Many observers in the past have noted that the anti-scurvy value of fresh meat, though significant, was much inferior to that of vegetables and fresh fruit. Nansen and Johansen, after leaving the *Fram*, spent nine months, including the winter of 1895–96, on Frederick Jackson Island in a rudely constructed hut. They remained in good health and free from scurvy, although obtaining no lemon juice and no fresh vegetables, and subsisting mainly on fresh walrus and bear meat preserved by the arctic cold.

Jackson and Harley (1900) describe an interesting incident at Kharborova, Yugor Straits, where six Russian priests arrived in the autumn, attended by a small Russian boy. The priests by their religious vows were prevented from eating the fresh meat available: they subsisted on salt fish and there were no vegetables. In the following May the little boy was found to be the only surviving member of the party, and had buried all his late masters in the snow. He suffered from no religious disability and had fed largely on reindeer meat through the winter.

A Classical and War-time Experiment on the Distribution of Vitamins B_1 and C.—The deficiency of vitamin B_1 in white wheaten bread is under ordinary conditions made good by the varied diet enjoyed by Europeans. If, however, a mixed diet is derived from canned and preserved foods the case is otherwise, and beri-beri may be expected to appear. This was, no doubt, the cause of the beri-beri which was reported among our troops in the Great War, 1914–18, in the Dardanelles and in Mesopotamia (Wilcox, 1916). In the latter campaign it is illuminating to note that the disease was confined to the British troops and was not reported among the Indian soldiers. This immunity was to be expected, for, in addition to atta, a coarsely ground whole wheat flour, the native soldier received a generous daily ration of dhal or dry pulses of various kinds, which are rich in antiberi-beri vitamin.

The difference between the types of cereal ration issued respectively to the British and Indian troops was the basis of an experiment which took place unwittingly during the siege



FIG 34.—Children 6 years of age showing severe rachitic deformities compared with normally grown child (centre) of the same age [*By courtesy of Dr Chick. Crown copyright reserved*]

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per day, the child would receive 36 mg. vitamin C which is sufficient for a child up to 12 months of age.

Vitamin C is essential for growth and therefore children require more than adults. The daily allowances recommended by the National Research Council, U.S.A., for children of 5, 8, 11 and 14 years, are 50, 60, 75 and 90 mg. respectively.

The international unit of vitamin C is 0·05 mg. pure L-ascorbic acid.

Loss of vitamin C in foods during storage and preparation is important. For example, potatoes in storage may lose 50 per cent of their original vitamin C content, depending upon the length of time they are stored. If, however, potatoes are left

TABLE 40

ASCORBIC ACID (VITAMIN C) IN FOODS—EDIBLE PORTION

	Mg per 100 grams	Wastage per cent	As purchased, mg per 100 grams
Currants, black	200	0	200
„ red	45	0	45
Oranges	35	25	41
Gooseberries	40	0	40
Grapefruit	40	50	20
Strawberries	60	3	58
Pineapple	20	50	10
Tomatoes	25	15	21
Blackcurrant jam	20	0	20
„ puree	65	0	65
Orange juice (M. of Food)	160	0	160
Rosehip syrup	150	0	150
Asparagus	60	80	12
Brussels sprouts	100	25	75
Cabbage	70	30	49
Cauliflower	70	30	49
Horse-radish	130	55	59
Kale (uncooked)	130	30	91
Parsley	150	0	150
Potatoes (early)	30	7	28
„ (late)	10	25	8
Turnip tops	100	25	75
Watercress	60	15	51
Swedes	40	35	26
Lemon juice	50	0	50
Lime juice	45	0	45



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(To face Fig. 3)



Fig 35—Rickets in an English infant. Note the deformity and enlargement of the epiphyses at the wrist [*From Dr Donald Hunter, by courtesy of Messrs Wm Heinemann, Ltd*]

[*To face Fig. 36.*

until sprouting begins or is about to begin, the vitamin content increases and the original amount may be almost wholly restored.

The shortage of citrous fruits during the war aroused a certain amount of interest in the sprouting of legumes Bean sprouts are well known in China, where much use is made of young growing vegetable foods. In this country if it is wished to increase the vitamin C content of legumes (peas, beans) it would be necessary to soak them in lukewarm water for 24 hours, and, having drained them, to allow them to germinate for 4 or 5 days. In China they are generally kept on a piece of matting in a wooden receptacle with small holes in the bottom to allow the warm water to filter away slowly Good drainage prevents the lower layer of beans from rotting and also mould formation, which is apt to occur if too much warm water is used. The aim is to produce succulent shoots by a slow process of germination extending over one week

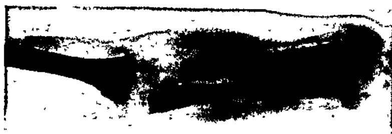
It is, *therefore, necessary in considering* the supply of vitamin C to be aware of the changes that take place in storage, preparation, cooking and serving. It must not, however, be assumed that a loss of vitamin C condemns any vegetable; it will still provide its quota of Calories, protein, iron and mineral salts.

In assessing the value of vegetables as sources of vitamin C the percentage content of the edible portion may be misleading. Account must be taken of the kitchen wastage; this is noted in Table 40, column 2. With foods which are exposed to damage in storage and wastage in preparation, it is best, knowing the risks, to take the vitamin content of the food as purchased as an indication of its vitamin value.

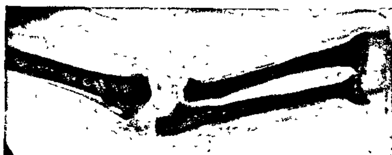
VITAMIN D

Vitamin D is a fat-soluble substance which has the power of controlling the deposition of calcium and phosphorus in the tissues. It is necessary for the optimum utilization of these elements, both by maintaining normal assimilation and preventing abnormal loss. While the growth of bones and teeth have been most closely associated with this vitamin, it must be remembered that all growth and repair are dependent upon the good utilization of the minerals for which this vitamin is essential. It must, therefore, not be neglected as something of value in the nutrition of adults. The part played by vitamin

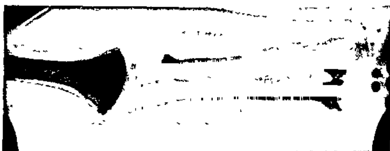
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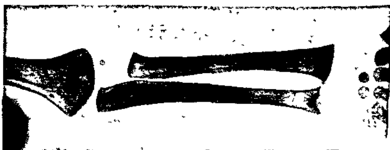
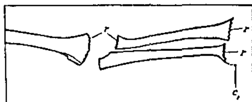


Fig 37 —For detailed description of above photographs see Fig 38

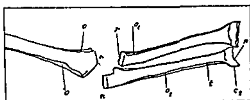
[By courtesy of Dr. Chick, Crown copyright reserved]

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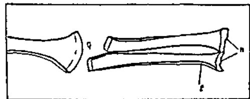
H K Case No 89 Admitted with rickets, treated with cod liver oil



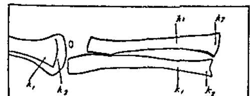
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3. (1) [illegible]



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FIG. 88.

D in securing the full development of the body is best illustrated by a consideration of the vitamin D deficiency diseases known as rickets and osteomalacia. These are diseases of mineral metabolism wherein the abstruse chemical changes concerned with bone formation do not proceed normally. Rickets is a disease of children (see Figs. 34 to 40), osteomalacia is its manifestation in adults, where in adolescents or in women at pregnancy the bones are robbed of their calcium and phosphorus. The characteristic naked eye manifestations of rickets are to be found in the long bones and the ribs (Figs. 37 and 38). Rickets is due to a deficiency of vitamin D which causes disturbances in the utilization of calcium and phosphorus. The bony changes referred to depend on the rate of growth and the stress and strain upon certain bones at different times in the life of the child (Figs. 35 and 36). The child crawling on hands and knees will show enlargement of the epiphyses at the wrists; when the child begins to walk, the stress and strain are transferred to the legs, unless the signs at the wrists have been duly noted, the femur and tibia will begin to develop characteristic curvatures and thickenings which to naked eye observation will be seen first at the ankles. Other signs are enlarged head, flabby muscles and relaxed ligaments. The deformities are the result of a loss of natural rigidity due, in the absence of sufficient calcium and vitamin D, to a failure of correct bone formation. The deformities of 20 years ago are not so frequent to-day: the bow legs, the anterior curvature of the shin bones, the knock knees, the narrow pigeon chests and spinal curvatures are fast disappearing (Fig. 34). But do not let it be forgotten that even when the naked eye manifestations of the disease are absent, X-ray examinations of the long bones in infants may still reveal the presence of rickets (see Figs. 37 and 38). Radiological evidence of rickets in apparently healthy normal children is not uncommon to-day. Rickets is a disease which has no geographical boundaries. Not so is it with osteomalacia to-day. This is a disease most commonly met in India and China. In India the custom of purdah, practised by Mohammedan and high caste Hindu women, prevents their exposure to the rays of the sun; this, coupled with a diet consisting chiefly of cereals, poor in meat, with very little milk fat—for the quality of milk in India is invariably poor—leads to faulty bone development. The diet lacks calcium, phosphorus and vitamin D. In China the

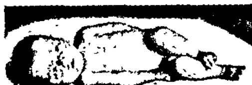


FIG 39.—A. H K., aged 10 months, admitted with rickets Bossing of head extreme, muscular weakness considerable Treated with cod liver oil [*By courtesy of Dr Chick, Crown copyright reserved*]



FIG 40.—B H K., aged 14 months Healing of bone lesions almost complete marked improvement in head contour General condition improved [*By courtesy of Dr Chick, Crown copyright reserved*]

[*To face page 190*

dietary conditions are practically the same; millet, rice, a limited amount of poor vegetables, almost no meat or eggs, and in inland China, no fish. Could one expect anything but disaster from such a diet. Professor J. Preston Maxwell showed many years ago that there was a very close relationship between the increase in the cultivation of the poppy—with an increase in the use of opium—and the increase of osteomalacia in the province of Shansi. Opium smoking and the binding of the feet of children in China have, because of the enforced seclusion to the house or high-walled courtyard, been definite factors in the ætiology of osteomalacia. In the East osteomalacia is most commonly associated with pregnancy and lactation; it is also due directly to a deficient intake of calcium, giving rise to what has been called 'non-tropical sprue'. The calcium of the blood is not markedly lowered in uncomplicated rickets, but the reduction in inorganic phosphorus is a valuable indication of the degree to which rickets has developed. A low serum calcium or phosphorus is not necessarily proof of rickets, for other conditions alter the content of these minerals in the blood. There is in the blood plasma an enzyme, plasma phosphatase; several investigators have found that it is increased in rickets and its estimation is a valuable indication of early rickets, a condition which is difficult to detect clinically or radiologically.

It was proved many years ago that rickets was not due to a deficiency of calcium *per se*. Rickets can be produced in rats by feeding a diet rich in calcium but low in phosphorus and can be readily cured by increasing the phosphorus. The addition of butter fat to such a rickets-producing diet was not altogether satisfactory in curing the disease. On the other hand, cod-liver oil proved most effective. With regard to the part played by cod-liver oil it was found by many workers on both sides of the Atlantic that if oxygen were passed through the heated oil, its growth-promoting vitamin A was destroyed but its antirachitic factor was not. This factor was separated from the fat of the cod-liver oil by Dr. Zucker of Columbia University in 1921 and named vitamin D by Professor McCollum.

It will be remembered that in dealing with the mineral salts of the body reference was made to the deficiency of calcium in the diets of Europeans and Americans. Pre-war surveys covering several of the chief towns in Scotland revealed in some cases an alarming lack of calcium

example, some 15 years ago, it was found that taking the highest standards for calcium requirements, which include that for growth, *the necessary intake of calcium was only attained in* 9 out of 37 families examined. Rickets, a disease of "poverty and darkness" *is found almost exclusively in those children* who, living in the slums of great cities, are never well fed and are exposed but little to the direct rays of the sun. In India, where children are allowed to play in the sun, in contrast to the children of the higher castes who are kept with their parents in purdah, rickets is practically unknown. In the Arctic regions where sunshine is limited to a short summer, children are adequately protected from rickets because their mothers, who eat a diet rich in fish oils and fat meat, nurse them over a *long* period and, *after weaning, the children begin early to eat* vitamin-containing foods, such as fresh fish and fish livers.

A striking testimony to the value of vitamin C and the fat-soluble vitamins A and D is given in Fig. 41. The legend to the figure describes the treatment of the experimental subject and the control, and is a tribute to the work of Drs. Harriette Chick, Hume, Dalyell and others of the Lister Institute, London, which was carried out in Vienna for several years following the Great War of 1914–18.

What Is Vitamin D?—*How does the sun produce vitamin D in the body?* It does so in virtue of the fact that the ultra-violet rays of the sun act upon ergosterol, a provitamin present in the fat of the skin and thereby produce the vitamin. As one might suppose, there is a great body of evidence behind such a statement. A clue directing experimental attack in the right direction was supplied, rather unexpectedly at the time (1922), by the discovery that the effect of irradiation of the animal could be equally well produced by irradiation of its rickets-producing diet. *The experiments consisted of feeding* one series of rats on a diet deficient in fat-soluble vitamins, of which one is vitamin D, i.e. a purely rickets-producing diet, and another series on a similar diet after it had been exposed to the light of the mercury vapour lamp or to the direct rays of the sun. *The rats on the irradiated diet grew excellently* and showed no signs of rickets; the others quickly developed the disease. *It was further observed that cod-liver oil could* thus be adequately replaced, and it was later found that irradiated liver was of value in preventing rickets. Further research



FIG 41.—A photograph of twins, taken in a Vienna infants' home in 1921, illustrating the striking effect on backward children of medication with anti-scorbutics and fat-soluble vitamins. Six months before the date of the photograph the girl, Ida P. (left), at 22 months old, weighed 7 6 kg (35 per cent below normal); she could neither sit nor stand and made no attempt at spontaneous movement. She had only four teeth, an open fontanelle and other signs of rickets and in her previous history two attacks of scurvy had been diagnosed and treated. During 6 months of treatment, extending from December to June, in addition to the ordinary institution diet which contained an adequate supply of milk, she received daily, 20 g. raw swede turnip juice (occasionally substituted by raw lemon or orange juice) 10 g. butter, later increased to 20 g., and for the last 3 months 10 g. cod-liver oil in addition. At the end of the period she weighed 11 1 kg. (11 per cent below normal), she had 12 teeth, the fontanelle was closed and there was striking remission in all signs of rickets. She could stand and walk a little, she tried to talk and was transformed into a cheery, active little girl.

A control was provided in her twin brother Johann (right) who had also been in the same Institution since birth, and also had suffered from scurvy during the first year of his life, complicated with rickets. While his sister received treatment, however, he had remained in another ward in which no extra vitamin therapy was given. At the time of the photograph, at 28 months of age, his condition exactly reflected that of his sister before treatment. He was feeble, anæmic, showed signs of severe rickets, was unable to sit without support, and gave no signs of intelligence [*after Chick and Dalyell by courtesy of Brit. Med.*]

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known from clinical experience that many children, although receiving adequate amounts of vitamin D in their diet, derive benefit from irradiation by U.V light.

It may be of interest to know that breads have, in the past, been available to which irradiated ergosterol, in standard quantities, has been added without affecting the taste. Milk has had its low vitamin D content increased by direct exposure to artificial light under suitably controlled conditions, by addition of a standard amount of a fat-free concentrate from cod-liver oil, or by feeding irradiated yeast to cows. With regard to the specific rays of the sun necessary for producing vitamin D, it should be emphasized that they do not pass through ordinary window glass. Direct exposure is necessary, but reddening of the skin should be a warning against excessive exposure, which would ultimately lead to destruction of the vitamin. Controlled exposure slowly causing tanning of the skin should be the aim of all sun bathing The possibility of correct exposure depends on the place, the season and the time of day; in cities, most of the violet-rays are screened out by smoke and dust, in a country with a winter climate such as ours, with its clouds and moisture-laden atmosphere, the only way for children to secure an adequate amount of vitamin D is to take halibut or cod-liver oil or some concentrated preparation of these oils All concentrated preparations of the vitamin should be taken according to the stated directions for dosage There is perhaps a slight risk of overdosage, particularly by enthusiastic persons and this is not without its dangers. To attempt to increase weight, to strengthen bones, particularly of children, by large doses of vitamin D and calcium salts may bring about loss of weight, calcification in arteries, kidneys and muscles. This, of course, is not easily done, but a warning is necessary, especially when some of these preparations are many times more powerful than cod-liver oil.

While research has not yet indicated the manner of action of vitamin D in the body, it is true that its main effect is on phosphorus metabolism and that alterations in calcium metabolism are secondary. The early signs of deficiency are an increased excretion of phosphate from the body, a fall in the inorganic phosphate concentration in the blood plasma and an increase in the phosphatase of the blood. The failure

revealed the essential fact, that the capacity to become activated resided in those constituents of the diet which contained fats.

Fats, such as olive oil, cotton-seed oil, vegetable oils inactive in themselves, became markedly antirachitic on irradiation. The part of the fat which is essential contains two closely related substances, ergosterol and cholesterol, which contain fatty acids as an integral part of their structure; only certain rays of the sun with wave-lengths between 280 and 310 millimicrons will activate these sterols. The relationship between the mineral salts, the fatty-acid containing substances in foods and in the skin, and the ultra-violet rays of the sun, has been scientifically established.

Ergosterol and cholesterol belong to a group of compounds which have diverse physiological functions; they include bile acids, male and female sex hormones, hormones of the adrenal cortex, some of the carcinogenic hydrocarbons and vitamins of the D group. A pure white crystalline substance isolated as one of the end products of ergosterol irradiation was named calciferol or D_2. This product in large doses will cause loss of weight and deposition of calcium salts in the heart and large arteries. It is strongly antirachitic; 0·025 μg. of calciferol is the League of Nations standard unit for vitamin D activity. Vitamin D_2 is not identical with the vitamin in cod-liver oil which is generally designated D_3. The cheapest source of vitamin D is sunlight, which forms vitamin D_3 from another sterol in the skin, namely 7-dehydrocholesterol. Vitamin D_3 is the natural vitamin D of man. There has been and still is some disagreement concerning the relative values of the synthetic vitamin D_2 (calciferol) and the natural vitamin D_3. The result of feeding groups of ten chicks on these two vitamins is shown in Fig. 42; the chicks receiving the natural vitamin D_3 from cod-liver oil had an average weight of 399 grams; chicks receiving vitamin D_2, 346 grams; chicks receiving no vitamin, 259 grams. The naturally fed group suffered no deaths during the period of feeding; of the others, the D_2 group had a mortality of 50 per cent, and the "no vitamin" group 60 per cent. The advantages of giving vitamin D_3 in its natural form in cod-liver oil are that it provides vitamin A, a toxic dose of the vitamin cannot be given because of the large amount of the oil which would be required to approach toxicity and it provides a high proportion of essential unsaturated fatty acids. It is



FIG. 42.—Five weeks old chicks. The bird on the left received natural vitamin D_3 from cod-liver oil, the bird in the centre received the same number of International Units of synthetic vitamin D_2 (calciferol), and the bird on the right received no vitamin D. The average weight and mortality of the ten birds in each group were: with the natural vitamin 390 grams and no deaths; with the synthetic vitamin 346 grams and five deaths; with no vitamin 250 grams and six deaths. [*By courtesy of British Cod Liver Oil Producers (Hull), Ltd.*]

or delay in ossification in rickets is not primarily due to a defect in the bones themselves; the biochemical lesion may be a lack of the correct balance of calcium and phosphate ions necessary for the osteoblasts to bring about a correct deposition of bone. The result of this is clearly shown in X-ray pictures where the line between cartilage and bone formation is shown to be irregular. In prolonged deficiencies there may be a marked reabsorption of calcium and phosphate from the bone, thereby rendering the bone weaker and unable to bear the stresses and strains normally placed upon it. If the vitamin is not given early and the bones are therefore allowed to ossify in their abnormal shape then the deformities produced are permanent. It is thus seen that rickets is a disease of the growing animal; in adults a deficiency of vitamin D leads to osteomalacia, where there is a reabsorption of bone already laid down. This condition has been referred to and is of particular importance in pregnant women where the absorption of the mineral salts is insufficient to meet the needs of the fœtus.

It should be noted that vitamin D is soluble in mineral oil and therefore the administration of liquid paraffin may play a definite part in preventing the absorption of vitamin D.

Human requirements of vitamin D are difficult to estimate correctly. The amount of vitamin D formed in the body depends on such factors as climate, season, age and sex. There is a great variability of vitamin D in foods, and only a few foods are richly supplied. Experience in children's clinics has shown how much cod-liver oil is required to prevent rickets and to keep a child robust; one teaspoonful of cod-liver oil, containing 450 international units of vitamin D_3, appears to be sufficient for babies, children and adolescents. In the artificial feeding of infants it should be given in appropriate amounts with each bottle of milk: this ensures the fullest activity of the vitamin in the retention of the mineral salts—calcium and phosphorus. Growing children, pregnant women and nursing mothers should have at least 1·5 grams of calcium and 2·0 grams of phosphorus per day. While the adult requirement is not accurately known, it is generally maintained that a nursing mother should have about 800 i.u. per day.

Sources of Vitamin D in our Foodstuffs.—The best sources by far are cod- and halibut-liver oils. All fish livers, and particularly those of fatty fish, are rich in vitamin D.

Fresh or tinned herrings, sardines, kippers, pilchards, salmon are of value. Egg-yolk is a very excellent source and therefore eggs are valuable. Cheese is a fairly good source, butter, however, is variable, but because of the quantity of these foods used in the diet, they are regarded as good sources. The vitamin D value of dairy produce and fish varies with the seasons; in summer, for example, hens' eggs may contain three times as much of the vitamin as they do in winter. Seasonal variations in the vitamin D content of butter are great; the range is approximately 70 to 350 i.u. per 100 grams (20 to 100 i.u. per oz.).

TABLE 41

VITAMIN D IN FOODS

	I.U. per 100 grams		I.U. per 100 grams
Herring	350	Margarine (vitaminized)	210
„ (canned)	160		
Mackerel	700	Liver	45
Salmon	600		
Sardines (canned)	1,000	Tuna liver oil	85,000 to 1,000,000
		Halibut liver oil	20,000 to 400,000
Egg-yolk	150	Mackerel liver oil	75,000
Eggs, whole	60	Cod-liver oil (Ministry of Food)	20,000
Butter (Empire)	60		

During winter and spring both the flesh and liver of herring have a much lower fat content than during summer and autumn, the maximal range being 4 to 20 per cent of fat. Since the vitamin is associated with fat, it is clear that herring caught in the summer and autumn must have the largest amount of vitamin D. The importance of sunshine for cows, poultry and fish is evident. During the war, margarine was fortified by the addition of 210 i.u. of vitamin D per 100 grams (60 i.u. per oz.). There are no butter fats in margarine, and even if it is fortified with vitamin D_3—not vitamin D_1 nor D_2—it cannot be regarded as a perfect substitute for butter. The emphasis must ever be on the natural foodstuff.

TOCOPHEROL (Vitamin E)

In 1920 it was observed that rats on special milk diets suffered disturbances in the function of reproduction. Two years later the factor responsible for the failure of rats to reproduce was recognized by Evans of California as a vitamin,

Much interesting work is being carried out on the relationship between vitamin E and the endocrine organs—thyroid, pituitary, ovaries, testes, etc., as well as on its relation to the function of nerve and muscle. The knowledge of the human requirements of the tocopherols is still very meagre. The best form in which to give the vitamin is whole wheat germ.

VITAMIN K (Coagulation Vitamin)

A scorbutic-like condition with subcutaneous hæmorrhages was found in chicks to be due, not to ascorbic acid but to this new factor, discovered by Dam and Schonheyder in 1936. It was called vitamin K because of its suspected influence upon the regulation of the processes of blood coagulation (Koagulations Vitamin: Danish and German name).

TABLE 43

VITAMIN K IN FOODS

	Dam units per 100 grams		Dam units per 100 grams
Fish meal	90,000	Alfalfa	20,000
Cabbage leaves	55,000	Tomato (green)	10,000
Spinach leaves	55,000	" (ripe)	5,000
Cauliflower	40,000	Liver	5,000
		Carrots	1,000
		Potatoes	2,000

Vitamin K is fat-soluble; its absorption from the alimentary depends upon bile salts.

It is now known that this vitamin plays an important rôle in the regulation of the normal function of the liver. A small amount of vitamin K is stored in the liver, but small though the amount be, its presence there is essential for the formation of prothrombin, a substance which, in the presence of ionized calcium salts, is quickly converted into thrombin, an enzyme or ferment which acts just as does rennin in the coagulation of milk, except that it coagulates the blood by [illegible]

tine, vitamin K is inadequately absorbed and the prothrombin of the blood is lowered. To reduce the death-rate from hæmorrhage in new-born babies vitamin K is given to the newly born child or, what is far better, to the mother before the birth of the child.

and in 1936, Evans and several co-workers isolated three different vitamins E, which they named α-(alpha), β-(beta) and γ-(gamma) tocopherol. The name tocopherol, from its Greek derivation (tokos = childbirth; phero = to bear), indicates precisely the activity of the vitamin. The inability to bear young lay in damage to the placenta, occasioned by a lack of the vitamin in the diet. Other known vitamins and protein as possible factors were excluded. Lettuce dried and heated to destroy vitamin C exerted a curative influence, as did also oil of the wheat germ from which the fat had been removed. When vitamin A is deficient in the diet over long periods, ovulation ceases and generally implantation of the ovum does not take place. Lack of thiamine seriously disturbs the œstrus cycle, while a

TABLE 42

TOCOPHEROL (VITAMIN E) IN FOODS

	mg per 100 grams		mg per 100 grams
Wheat germ oil	520	Lettuce (dry)	55
Wheat germ	26	Olive oil	8
Bread (brown)	2	Meat	1
„ (white)	1 5	Liver	3

deficiency of vitamin C leads to disastrous changes in the corpus luteum, the basic structure upon which the development of the placenta and the embedding of the fertilized ovum depends. Vitamin E does not apparently play its part until about one-third of the gestation period has passed, and then death of the fœtus may occur indicating a serious deficiency of the tocopherols. Other manifestations of deficiency appear in different species of animals; nutritional muscular dystrophy may, for example, appear in rabbits, sheep and man.

The vitamin is not formed in the animal body but is synthesized in plant cells, probably in the green part of the plant, and is transferred to the seeds, e.g. wheat germ. Chief sources of vitamin E are wheat germ and green leafy vegetables of which lettuce is very good. White flour contains none: the loss of germ from the wheat results in the loss of several valuable nutrients.

The international unit is 1 mg. of alpha-tocopherol acetate. The human requirement is about 3 mg per day.

Much interesting work is being carried out on the relationship between vitamin E and the endocrine organs—thyroid, pituitary, ovaries, testes, etc., as well as on its relation to the function of nerve and muscle. The knowledge of the human requirements of the tocopherols is still very meagre. The best form in which to give the vitamin is whole wheat germ.

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Vitamin K is fat-soluble; its absorption from the alimentary depends upon bile salts.

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[illegible]

or, what is far better, to the mother before the birth of the child.

It must be stated that vitamin K is not of value in the treatment of hæmophilia, that is, a condition where there is a hereditary tendency to bleed profusely from even slight wounds.

Of human requirements the adult amount is not known, but of its importance there is no doubt.

Vitamin K is found in green leafy vegetables, tomatoes, egg-yolk and liver. The green tops of carrots contain vitamin K but the root contains none. Synthesis is markedly influenced by sunlight, and therefore vegetables, e.g. peas, grown in the dark, will contain very small amounts of vitamin K.

NUTRITIONAL LOSSES IN FOOD PREPARATION

The Effect of Cooking on Minerals and Vitamins

The preparation and cooking of foods always results in a variable loss of nutrients, more particularly of vitamins and mineral salts. The loss of nutrients is caused by expression of juices, leaching by boiling water or condensed steam and hydration. Many vegetables, for example, potatoes, suffer little or no loss of water soluble constituents; others, such as carrots, swedes and parsnips may lose up to 30 per cent of water soluble substances, while for some, e.g. Brussels sprouts and cabbage, the loss appears to be small. The main cause of loss is the leaching action of the water.

With regard to particular minerals, reference may be made to calcium. In the boiling of vegetables, much of the calcium forms insoluble salts which are not removed by leaching. *Interesting is the result of boiling vegetables in hard water as* compared with distilled water; McCance and others have shown that there may be substantial increases in the calcium content of vegetables boiled in hard water, and of iron, where weak acids, liberated during cooking, have dissolved iron or iron salts from the cooking vessels. The addition of sodium bicarbonate *increases slightly the loss of water soluble salts*, but this is offset by the shortening of the cooking time when hard water is used.

Boiling and frying, so far as potatoes are concerned, results in a loss of water only.

In a paper on this question Dr. C. P. Stewart of the Clinical Laboratory, Edinburgh Royal Infirmary, states: "It is worth while to consider what these losses, which seem so large when

expressed as a percentage of the amount present in the raw vegetables, amount to in terms of actual quantities in relation to the daily intake. The following Table shows the mineral losses as compared with the intake from potatoes, carrots and peas in an ordinary meal."

MINERAL LOSSES IN COOKING COMPARED WITH DAILY INTAKE

	Potassium	Calcium	Iron	Phosphorus
	mg	mg	mg	mg
Potatoes 150 g . .	144	1 0	0 27	4 5
Carrots 50 g . .	40	3 4	0 10	2 0
Green peas 50 g . .	76	0 75	0 20	10 5
Total loss . .	260	5 15	0 57	17 0
Daily intake	3,400	700	14	1,400

"Though the losses of minerals, as well as of carbohydrate and protein during the cooking of vegetables appear to be of little nutritional importance, that is merely because the foods are very minor sources of these substances of which the percentage losses are or may be considerable."

The losses suffered by the vitamins may be briefly stated

Vitamin A.—In domestic cooking there is no appreciable loss; this is due to the fact that vitamin A is not readily soluble in water and is not destroyed by heating, freezing, preserving or canning. Evaporation of milk, as in the process of drying, causes no loss.

Vitamin B_1 (Thiamine).—When foods are heated in an acid medium, if to not more than 120° C. (248° F.) there is no loss. [illegible]

larly destructive of vitamin B_1. Important, too, is the reaction, that is, the acidity or alkalinity, of the water in which the foodstuff is cooked. If it be definitely acid, very little will be lost, provided the temperature is regulated; if alkaline, the loss will depend upon the degree of alkalinity. Baking soda should not be used in the boiling of vegetables, and water should be kept as minimal as possible. Vitamin B_1, unlike vitamin C, is not destroyed by atmospheric oxygen.

Vitamin C.—If in an alkaline medium, this is the most easily destroyed of all the vitamins, but, under ordinary conditions of cooking, where the cooking medium is not alkaline, the loss is not so great as has been previously suggested. Vegetables and fruits contain an ascorbic acid oxidase, an enzyme which, when vegetables and fruits have been gathered, slowly destroys the vitamin. There are in vegetables protective organic acids which do not allow of such a quick destruction of vitamin C as many have thought. The enzyme is killed at 100° C. : therefore vegetables, etc., should be placed, in small amounts, into boiling water—in small amounts in order to prevent too great a lowering of the temperature of the water. Certain metals are destructive of vitamin C. They are copper and iron ; therefore copper and iron pots and pans should not be used if vitamin C is to be preserved. Enamel, pyrex glass, stainless steel have no bad effect on vitamin C. The best advice is to place the foodstuff in boiling water, boil rapidly in a conveniently small amount of water, keep the lid on and serve without unnecessary delay. Since 10 to 20 per cent of vitamin C will be extracted, the cooking water should be kept and used Artificial drying and pickling and pasteurisation are deleterious, as are slow methods of cooking. Concerning potatoes, which are a reliable source of vitamin C, the best procedure is to bake them in their skins, the second best is to boil rapidly as has been suggested for vegetables. It has been found that in large-scale cooking, potatoes lose 85 per cent of their vitamin B_1 and 45 per cent of their vitamin C. If left standing on a hot plate, the losses increase to 70 and 75 per cent respectively (Nagel and Harris, 1943). The worst procedure is to mash them, for by so doing, the surface of the potato is increased a thousand fold and oxidation of the vitamin proceeds rapidly.

A good example of what may happen to vitamin C during the period from its preparation to its being served is what may happen in the potato. A whole potato weighing 100 grams (3½ oz.) containing, say, 12 mg. of the vitamin, loses 2 mg. in preparation and boiling, and, if served whole and eaten without delay, loses little more. But if it be mashed, thus accelerating oxidation processes which destroy the vitamin, it may contain only 5 mg. on serving, and if kept hot for 30 minutes, this figure may be further reduced to 3 mg. or less when the potato is finally eaten. A similar statement can be made about

green leafy vegetables; 100 grams may contain, when bought, 20 to 40 mg. of vitamin C, after preparation and cooking they may contain only 10 to 30 mg, and on serving, 2 to 5 mg.

Vitamin D.—Since vitamin D is not soluble in water and is not affected by heating, freezing or canning, little or no loss occurs in the storage, preparation and cooking of food.

Vitamin E.—Under ordinary methods of cooking, there is no known loss of vitamin E. Loss of the vitamin is associated with rancidity of fats. This is particularly true of synthetic or concentrated preparations of vitamin E. It may be surprising to some to learn that most foods containing fat are never entirely fresh when prepared for the table; fat slowly deteriorates, becomes stale and consequently some vitamin E is destroyed. Pasteurised milk, cheese, butter, etc., may be stale when consumed. If it be desired to secure the optimal absorption of vitamin E in children, it should not be given within three or four hours of the administration of cod-liver oil.

The losses of protein and fat from meat and fish are very variable and it is difficult to assess their nutritive importance. As with vegetables, the losses appear large when expressed as a percentage of the amounts in the raw food, but are insignificant in relation to the total daily intake.

Pressure Cooking.—The increased use of pressure cooking, so economical of fuel and time, raises the question of its effects on nutrients, chiefly because of the greatly increased temperature compared with that of open methods. Loss of nutrients in cooking is generally caused by leaching, oxidation, temperature, the time taken in reaching the maximal temperature and over-cooking. Leaching is controlled by using minimal and appropriate amounts of water; oxidation is prevented by the anærobic conditions concomitant with an atmosphere of superheated steam; the rate of rise of temperature is increased by commencing the process with boiling water and raising the pressure quickly to 15 lb. per square inch or to 250–270° F.; and over-cooking, so destructive of tissue and enzymes, is avoided by experience. In view of the findings of several investigators (Chappell & Hamilton, 1949; Bakarian, 1949), it may be safely affirmed that with respect to carotene, thiamine, nicotinic acid and ascorbic acid, their retention in pressure cooking is not likely to be worse but probably better than in open methods.

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CHAPTER XII

BREAD

HISTORICAL INTRODUCTION

PREHISTORIC man, by some unknown method of selective breeding, cultivated those grains, the seeds of which could only be removed by trampling, shaking or beating. Four species of grain were known to the ancient Egyptians and to the Chinese as early as 3000 B C . they were millet, barley, wheat and oats Later rye and rice were cultivated, and only since the discovery of America has Indian corn or maize been known in Europe. The first authentic record which shows how largely grain harvests bulked in the economy of populations is the "Legend of the Seven Years' Famine in Egypt" which describes a period of terrible starvation caused by the failure of the Nile, for seven consecutive years, to reach its usual flood level and thus irrigate the land sufficiently The legend is also to be seen inscribed on a granite rock on the island of Sehel near Aswan and dates from the Ptolemaic period, although in its earlier form it may be as old as the IIIrd Dynasty, i e. about 2900 B.C The event to which the "legend" refers is associated with the famous Imhotep who first appeared "on the stage of history" as the vizier-physician of King Zoser. He it was who, as the Great Magician, advised Pharaoh to make the necessary prayers and supplications in the temple of the god Khnum and to propitiate him with offerings in order that famine might depart from the land. A similar seven years' famine in Egypt is recorded in Genesis xli 54, but, on this occasion, in all the land of Egypt there was bread. The whole economy of Egypt depended upon grain, which, in the final analysis, depended on that great gift of the gods, the rising of the Nile. Upon this event the Calendar was based ; Egypt's year was divided into three seasons each of one hundred and twenty days They were named "Flood", "Sprouting of Seed" and "Harvest of Grain", and the beginning of the first season, "Flood", was the first day of the Egyptian year, the day when Sirius appeared in the morning sky. The grain grown on the rich black earth left by the receding waters was made into bread

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between paganism and Christianity, between the believers in Odin, the wind god, and those who were anxious that, through religious influence, man should be taught to rule and use, to his advantage, the forces of nature. Through the long, dark mediæval age, agriculture and learning were stayed the one upon the other. With each recrudescence of paganism, and there were many, the land was laid waste and man suffered not only because of lack of bread, but because of bread poisoned by carelessness and ignorance in the cultivation of the soil. In A.D 943 thousands died as a result of eating bread made with rye contaminated by the ergot fungus. It was not until the end of the sixteenth century that the cause of this disease, known as Saint Anthony's Fire, was discovered. Throughout the Middle Ages the development of milling and baking was hindered by superstition and prejudice. Fear of the mill, hatred of the miller and suspicion of the baker, each played its part in stifling the spirit of progress. Hunger had always existed and recurring famines could only be accounted for on religious or supernatural grounds.

Bread, the fruitful basis of ecclesiastical controversy, the lack of bread, the cause of peasants' revolts and bitter national strife throughout England and the continent of Europe, bread became the watchword of those who demanded " the abolition of serfdom, the right to grind, bake and brew " (Wat Tyler, 1381).

England of the Roman occupation was to a very limited extent, in its southern and south-eastern areas, a wheat granary for the legions in Britain and on the Rhine. Before the Roman conquest, the chief crop grown was probably oats. Rye, a later addition, making its first appearance in Southern Russia, crossed the European plain, and finally crossing the North Sea to England in the Middle Ages, formed an important part of the food of the people. In some areas of the country more, in others, less rye than wheat was used in the mixture of these two cereals from which bread was made. In certain parts of England where the soil was well cared for, an early transition from rye to wheat began to take place. The reason for this is found in the thirteenth-century Book of the Office of the Seneschal where it reads " It is the duty of the Seneschal of Lands to protect his Lord's interests, to instruct the bailiffs of the several manors . . . to know how many acres there are

by the simple method of allowing the dough to ferment. Spores of yeast plants falling upon traces of sugar contained in the mixture of meal and Nile water, reduced the sugar to alcohol and carbonic acid gas; the alcohol disappeared, the gas raised the dough, thereby producing bread. The bread was baked in ovens, and in the course of time the bakers made use of sour dough, thus considerably reducing the time required for baking. In these early days of Egypt's greatness, bread was not merely the principal food, it was a mark of culture, a unit of measure and a means of remuneration. From this beginning the baking of bread spread slowly throughout the civilized world. In the slow decline of the Roman Empire, the cultivation of grain steadily diminished: Rome was paying the penalty for neglect of the fertility of the soil, and thus for hundreds of years she had to import grain from Egypt, Spain and North Africa. To Rome, Egypt was for many years a necessity since the gift of the Nile was bread. In the last century B.C. tens of thousands of people received free grain in the great capital of the Empire. In 30 B.C. the Emperor Augustus took possession of Egypt, and at home there was not bread enough for all. In A.D. 69 the revolutionary Vespasian seized the grain fleet ere it sailed from Egypt, had Rome at his mercy and, forcing recognition of his power, became Emperor. As long as Egypt was a Roman granary and in the hands of the Emperor, the proletariate and the army, particularly the latter, could be fed. But a dwindling Empire which, as a last resource, had to feed its legions in [illegible] corn from England, was a doomed Empire [illegible] character- [illegible] y of many.

When the [illegible] overran the Roman Empire, two important factors [illegible] the course of man's development; first, the necessity for nomadic tribes, if they were to live at all, to change the pattern of their lives and to abandon cattle raising in favour of agriculture; second, the impact of Christianity, which, under Constantine the Great, had been the State religion of the Roman Empire. As the centuries passed, the slaves became the serfs, and as they continued to multiply and till the soil in the interests of those who ruled over them, there emerged three classes; the land-owners, the serfs and the priests who, serving both, taught men the simple methods of agriculture. Here began the struggle

It is probably quite true that the system of ruthless land enclosures had put agriculture on a progressive basis, but at the expense of the economic life of the English countryside. The swift application of mechanical inventions in industry, the increase in population, the continued drift of the agrarian population to greater employment in towns and cities and the restrictions of the Corn Laws had created a situation in England which had within it the seeds of social revolution as dangerous as any in the history of France. The Industrial Revolution had thrown English agriculture into dire straits. In the midst of " the despair, fell disease and ghastly poverty " which marked the conditions of the great mass of the industrial working classes, the great call was for bread The repeal of the Corn Laws in 1846 gave the people bread, and then commenced the great importation of grain which has progressively increased ever since. The position which England held at the end of the eighteenth century as an exporter of wheat was quickly reversed and by 1860 she had become the largest importer of bread grains in Europe.

During the eighteenth century there was a complete transition from wheat and rye bread to purely wheat bread. The reason why rye did not continue to be the national bread corn in England as it did in Germany was because " the nature of the English loaf was closely associated with the nature of the English agrarian system which was not completed till the seventeenth and eighteenth centuries " (Sir Wm Ashley). By the revival of marling and liming, the soil was so improved that wheat became the more prevalent crop. It may be true that in the sixteenth and seventeenth centuries the cream coloured bread was the emblem of superiority. It may not be true, as frequently stated, that in the nineteenth century the desire of the working masses of England for white bread was an expression of envy and that " to eat brown bread was once a sign of lower class ". May it not be more probable that the " working classes " of the nineteenth century craved white bread for just those reasons which made white bread attractive to all who could afford it? It should be remembered that the white flour of the ancients, the maslin of the Tudors and the highly refined white flour of to-day are not one and the same article. A mortar and pestle, stone grinding, roller milling with varying methods of bolting do not produce a flour of the

in each field . . . to know how much wheat, rye, barley, oats, peas, beans one ought by right to sow in each acre". "He must cause the land to be marled, folden upon, dunged, improved and amended . . . for the advantage and betterment of the Manor." Great importance apparently was attached to the process of marling the land, by which fields were fertilized by spreading upon them marl, an earthy substance containing lime, clay and sand in various proportions. The well marled land produced good and assured crops of wheat: to sow two crops together in the hope that at least one would be successful was no longer necessary.

In Tudor times wheat and rye were closely associated; either grown together or the grain from separate fields mixed at the reaping. This mixture of wheat and rye, generally in equal proportions, was called "maslin" and from thoroughly sifted samples of it was made the cream coloured bread of the sixteenth and seventeenth centuries called "manchet". Sometimes wheat was mixed with both rye and barley to make bread, and bread made from such "mixt corn" with "white meats", i.e. milk, cheese and eggs, formed the chief source of sustenance of the yeoman and agricultural labourer up to about the end of the seventeenth century. From now, through the eighteenth century there was a steady decline in the use of rye. In the *Annals of Agriculture* of the year 1796 the following statement again indicates the transition: "in Nottinghamshire opulent farmers consume one-third wheat, one-third rye and one-third barley; but their labourers do not relish it and have lost their rye teeth". The increase in the use of white flour for baking bread and the ultimate disappearance of rye from English bread was associated with the growth of continental trade, the development of the wool industry and a steady deterioration in agriculture.

At the opening of the eighteenth century it could be said that the shearing of sheep became much more profitable than the growing of corn. The agricultural labourers were fast becoming "the slaves of the loom"; the land was deserted for the misery of slum life in crowded industrial towns. Goldsmith's dissertation on the evils of the transformation due to "Enclosures" is one of the treasures of English verse:

"Ill fares the land, to hastening ills a prey
Where wealth accumulates, and men decay".

It is probably quite true that the system of ruthless land enclosures had put agriculture on a progressive basis, but at the expense of the economic life of the English countryside. The swift application of mechanical inventions in industry, the increase in population, the continued drift of the agrarian population to greater employment in towns and cities and the restrictions of the Corn Laws had created a situation in England which had within it the seeds of social revolution as dangerous as any in the history of France. The Industrial Revolution had thrown English agriculture into dire straits In the midst of "the despair, fell disease and ghastly poverty" which marked the conditions of the great mass of the industrial working classes, the great call was for bread The repeal of the Corn Laws in 1846 gave the people bread, and then commenced the great importation of grain which has progressively increased ever since. The position which England held at the end of the eighteenth century as an exporter of wheat was quickly reversed and by 1860 she had become the largest importer of bread grains in Europe.

During the eighteenth century there was a complete transition from wheat and rye bread to purely wheat bread. The reason why rye did not continue to be the national bread corn in England as it did in Germany was because "the nature of the English loaf was closely associated with the nature of the English agrarian system which was not completed till the seventeenth and eighteenth centuries" (Sir Wm. Ashley). By the revival of marling and liming, the soil was so improved that wheat became the more prevalent crop. It may be true that in the sixteenth and seventeenth centuries the cream coloured bread was the emblem of superiority. It may not be true, as frequently stated, that in the nineteenth century the desire of the working masses of England for white bread was an expression of envy and that "to eat brown bread was once a sign of lower class". May it not be more probable that the "working classes" of the nineteenth century craved white bread for just those reasons which made white bread attractive to all who could afford it? It should be remembered that the *white flour of the ancients, the maslin of the Tudors and the* highly refined white flour of to-day are not one and the same article. A mortar and pestle, stone grinding, roller milling with varying methods of bolting do not produce a flour of the

same content or of a similar degree of whiteness. White flour was known to the ancient Greeks and was valued for the lightness of the bread made from it. Its production necessitated much manual labour, and its fine appearance was due to thorough grinding, efficient winnowing of the chaff and careful sifting. The stone ground corn of England was a valuable foodstuff, but stone grinding did not produce the fine, light article known to the Greeks and Italians probably as early as 200 B.C.

Modern milling is the result of a long evolutionary period of trial and error whereby the miller perfected his skill and improved his product. When roller milling was first introduced in 1830 in Switzerland by the engineer Sulzberger, the millers of Hungary quickly seized upon the idea and in a few years the white wheat flour of Hungary was flooding the world markets. But at the World's Fair in Vienna in 1873 American and English millers investigated for themselves the new technique, with the result that by 1880 roller mills had, in the U.S.A., virtually swept all previous forms of milling out of existence. To American wheat kings, who, upon the repeal of the English Corn Laws (1846), had captured the English market and later most of the continental ones, this was another boon. The North American continent had by 1900 become the world's greatest wheat granary. Following an exhibition in London, in 1881, of the new roller milling technique, British millers, finally realizing that the old method of stone grinding was doomed, gave up all opposition to the new method, and the British public got what they wanted, namely, white bread. The popularity of white bread lay not only in its more æsthetic colour, but in certain properties which it possessed. In the days when the housewife baked her own bread it was soon discovered that white flour had better rising properties. The improvement in baking due to finely ground flour was long known; indeed, it was the main reason for adding wheat or maslin to rye in the making of bread. Further reasons for the popularity of white flour at that time were the greater certainty on the part of the housewife in the final result of her baking, a finer cutting quality due to the finer texture of the bread and, to some, a much more attractive flavour. All these properties had no reference to nutritive values, for such were but dimly known. To-day, with scientific knowledge of the nutrients of bread and the possibility of improvement in baking techniques, there should

be no reason why the modern flour should be less fine than the best maslin or less nutritious than the coarsely extracted wheat berry of the Tudor period.

THE NUTRITIVE VALUE OF BREAD

The importance of the nutritive value of bread in any diet depends upon the nature of the diet. Where the dietary consists of a fair proportion of animal protein foods and vegetables, the rôle of bread in it is of far less importance than it is in a diet deficient in these protein, mineral and vitamin bearing foods. In certain parts of the world where cereals form the staple diet, the protein supplied by the cereal eaten is of importance. In the poorer families of the industrialized countries of Europe, bread is a highly important food factor; for example, in England in 1936 the amount of protein provided by bread and flour was 20 grams per day, which was 33 per cent of the total protein eaten by the poorest 10 per cent of the population. On the continent of Europe, in poor economic groups, the amount of protein from bread may be as high as 43 per cent of the total protein intake. The nutritional value of bread is further determined by the degree of extraction of the grain from which the bread is made, since the more highly refined the flour is, the less nutritious it becomes. Repeated extraction will produce a flour practically devoid of protein, mineral salts and vitamins, leaving only a carbohydrate foodstuff, excellent as a source of energy but valueless in any other respect. High carbohydrate diets require proportionately higher amounts of vitamin B_1 In the whole grains there is a sufficiency of vitamin B_1 to cover the demand made by the carbohydrate they contain; in bread made from highly refined flours there is little vitamin B_1.

In Western European countries the importance, as well as the amount of bread in the diet has decreased during the last fifty or sixty years, because there has been a marked increase in the consumption of meat, eggs, milk, butter, fruit and sugar. It is a well-known fact that the higher the standard of living, the greater will be the proportion of the total energy obtained from animal protein foods. One returns always to the obvious statement that, given a first-class diet, bread can be left to take care of itself. To some such a statement may close the subject, but to those interested in the health of nations it does

not, *at least* not as long as there are poor economic groups in our midst and under-nourished populations in the world. Bread is the cheapest of foodstuffs. There is no reason why it should be made the poorest by removing from the wheat berry the valuable minerals and vitamins which it contains. It could be made, and during the war was almost made, one of the best as well as the cheapest of foods. The consumption of bread in Great Britain compared with continental countries is not very high. In 1909–14 the consumption of wheat was 5·54 bushels, in 1930–31 4·86, and in 1936–37 4·69 bushels per head per annum. (Wheat Advisory Committee's Report, 1938). Until 1939 the bread was practically all wheat bread made from flour of 70 to 72 per cent extraction. Four classes of flour were milled (McDougall):

1. Bread flour from a mixture of strong and medium strength foreign wheats.
2. Pastry and cake flour from soft home or foreign wheat.
3. Biscuit flour almost wholly from British wheats.
4. Household flour either plain or self-raising from soft wheats.

The different grades of extraction were: (*a*) straight run grades to about 71 per cent; (*b*) short and long patents of 60 per cent and less; (*c*) a small amount milled for brown and wholemeal bread.

"Bleaching was permitted by law. While forbidden in many countries, bleaching has an advantage where the public insists on very white bread. It allows a greater extraction (71 per cent) which retains some vitamin B_1, while without it the extraction would have to be almost 64 per cent to secure the required whiteness in the bread. The bleaching processes (nitrogen peroxide trichloride, Beta gas or benzoyl peroxide) have been shown not to destroy the vitamin B content of flour" (McDougall).

Stone Milling v. Roller Milling

To understand the differences in the nutritive value of flours produced by these two methods, the structure of the wheat berry and the distribution of the nutrients in it must be known: they are shown in Fig. 43. The facts here presented are from a paper by Sir Jack Drummond and Dr. T.

Moran and were determined at the Cereals Research Station, St Albans, by workers whose object was to produce a flour of the highest nutritive value, having a pale colour and good baking quality (*Lancet*, June 1945). The findings are important. They show that 60 per cent of vitamin B_1 is in the scutellum fraction of the germ, nicotinic acid and iron are concentrated in the bran and in the outer endosperm, and the germ, as a whole, contains appreciable quantities of riboflavin, nicotinic acid and iron. In assessing the possible contribution of the different factors that can be made by endosperm and germ, it must be remembered that the amount of endosperm in wheat is 35 times that of the germ. The mineral salts and the Calories furnished by flours of different extractions have been determined by Professor McCance and his fellow-workers at Cambridge. It has also been found that proteins of high nutritive value are present in the outer layers of the endosperm. Bran includes the aleurone layer which, in milling, is not detached to any appreciable extent. In stone milling both the germ and the bran were ground so finely that they could not be removed by bolting, hence the cream colour of maslin The word "bolting" is derived from a corruption of the old French word "bure", the name given to the coarse woollen cloth used for sifting the flour.

In modern roller milling the wheat germ is not ground but flattened and the bran is flaked, and therefore both are easily separated from the flour in the process of bolting. The percentage of the nutrients in stone ground and roller milled flour is shown in the following Table.

TABLE 44

Nutrients	Stone ground Flour	Roller milled bleached Flour	Percentage loss in milling
Protein, g	12 5	10 11	19
Fat, g	1 4	0 9	36
Minerals, g.	1 1	0 4	63
Calcium, mg	44 0	20 0	54
Phosphorus, mg	180 0	92 0	50
Iron, mg	3 8	1 0	70
Carotene, mg	0 2	0 0	100
Riboflavin, mg	0 2	0 01	50
Aneurin, I U	100	15	85

The data in Table 44 form the basis of all discussions on bread to-day. *Note should be made of all deficiencies of 50 per cent and over.*

THE DISTRIBUTION OF NUTRIENTS IN THE WHEAT BERRY

The superiority of wheat over other cereals lies in its protein content, which, as McCance and Widdowson have shown, averages 13·62 in "hard" Manitoba wheat and 8·89 per cent in "soft" English wheat: the former has good, the latter rather

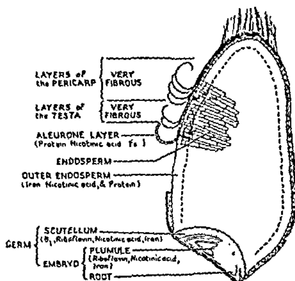


FIG. 43.—The distribution of nutrients in the wheat grain. (*Sir J. Drummond and Dr. T. Moran.*) [*By courtesy of Lancet*]

poorer baking qualities. Detailed examination of the wheat grain at the Cereals Research Station of the Ministry of Food has shown that the typical wheat grain consists of 12·3 per cent of bran, 83 per cent inner endosperm, 2 per cent outer endosperm, 1·2 per cent embryo and 1·5 per cent scutellum. The bran which consists of the pericarp, the testa and the aleurone layer, is rich in nicotinic acid, iron and contains appreciable amounts of thiamine and riboflavin. The proteins of bran contain about twice as much lysine and tryptophan as the proteins of white flour (Chick *et al.*, 1947). (See Fi . 43). The

distribution of nutrients in the wheat grain is uneven but from Table 45 it will be seen how valuable as a source of vitamin B_1 and nicotinic acid is the scutellum, a thin shield of powdery material lying between the embryo and the endosperm, and that the embryo, the smallest part of the wheat berry, is important in supplying riboflavin, nicotinic acid, iron and fat-soluble vitamins. If the scutellum, embryo, aleurone layer and the outer layer of the endosperm are kept in the flour, most of the vitamins, minerals and proteins will be retained. Recent work has shown that in wheat, maize and rice approximately 80 per cent of the nicotinic acid is confined to the aleurone layer. (Hinton, 1951).

TABLE 45

NUTRIENT CONTENT OF DIFFERENT PARTS OF THE WHEAT GRAIN
(Moran and Drummond, *Lancet*, 1945, p. 698)

Factor	Whole Wheat	Clean Bran, including Aleurone Layer	Scutellum	Embryo	Outer Endosperm	Bulk Endosperm including outer Endosperm
Vitamin B_1 (I U./g)	1 2	1 6	55	3	1 5	0 2
Riboflavin (μg /g)	1 6	5	15	15	1 8	0 7
Nicotinic acid (μg /g) . .	50	250	60	60	150	22
Iron (mg /100 g)	3 5	12	9	9	10	2 1
Approx % weight	100	12	1 5	1	3	85 5

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import
Food
extraction flour, " no flour from which a proportion of the germ had been extr
purposes ".
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flour, biscuits
very small percentage of the total flour used for human consumption.

From reports published regularly by the Scientific Adviser's Division of the Ministry of Food, one can follow the

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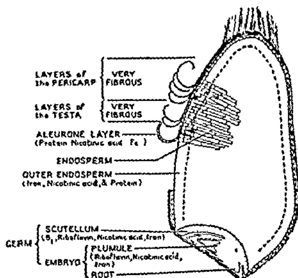


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changes in the composition, nutritive value and quality of the flour from which our national wheatmeal loaf is made. In the early months of 1943 most of the flour was enriched with calcium carbonate (*creta preparata*), 7 oz. to the 280 lb. sack, and again in 1946 with an additional 7 oz. of calcium carbonate. This has proved to be a most convenient method of adding to the calcium intake of the population, since despite the increase in the production of milk certain sections of the population do not receive their full quota of calcium. Bread experimentally produced is of good quality because in the laboratory it is baked under conditions in which water absorption, fermentation

TABLE 47

ANALYSIS OF COMMERCIAL FLOURS

(Moran and Drummond, *Lancet*, i, 698, 1945; and McCance *et al*, *Biochem J.*, 1945)

Factor	Rate of Extraction			
	100 per cent	85 per cent	82½ per cent	80 per cent
Vitamin B_1 (I U /g)	1 2	0 93	0 88	0 80
Riboflavin (μg /g)	1 6	1 3	1 0	0 85
Nicotinic acid (μg /g)	50	17	18	16
Iron (mg /100 g)	3 5	2 07	1 94	1 65
Fibre (%)	—	0 50	0 31	0 21
Colour index	—	100	41	11
Protein (g /100 g)	12 7	10 7	11 6	11 8

and temperature can be carefully controlled. Commercial baking does not apparently admit of accurate control of all these factors, with the result that, during the war, much of the bread was of only fair to good quality, the reasons being, incorrect fermentation of the dough, variations in water absorption, and insufficient baking. In Table 47, showing the results of analyses of commercial flours, the figures under 85 per cent extraction flour represent the average composition of the flour as stated in the fifth report covering samples received during January to June 1944 The figures in the 82½ per cent column are from commercially produced flours, data concerning which in fuller detail are to be found in the seventh report from the Scientific Adviser's Division of the Ministry of Food, 1945.

TABLE 46

A. COMPOSITION OF MANITOBA AND ENGLISH WHEATS (McCance *et al*, *Biochem Jour.*, 39, 215, 1945)

(Results calculated on a 15 per cent moisture basis.)

Percentage extraction	Protein (N × 5·7)	Fat	Carbo-hydrate (as starch)	Cal./100 g.	Fibre (g./100 g.)	Thiamine (Aneurin) (μg./g.)	Ribo-flavin (μg./g.)	Nicotinic Acid (μg./g.)	Calcium	Iron	Total P	Phytate P
	grams per 100 g.								mg. per 100 g.			
Manitoba												
100	13·62	2·49	63·0	328	2·15	1·18	1·7	55·0	27·6	8·81	350	242·0
85	13·57	1·70	67·2	339	0·33	0·92	1·0	13·3	18·5	—	188	96·1
80	13·22	1·43	68·8	341	0·13	0·65	0·8	11·0	15·4	—	139	63·4
75	13·03	1·32	69·5	342	0·10	0·29	0·7	9·6	13·1	—	100	39·8
70	12·77	1·18	70·0	341	Trace	0·22	0·7	8·4	12·8	—	97	30·0
42	11·80	0·66	71·2	341	Trace	0·09	0·5	7·0	11·1	—	82	14·0
English												
100	8·89	2·23	66·8	323	2·08	0·96	1·7	48·0	35·5	3·05	340	233·0
85	8·55	1·46	72·0	335	0·42	0·84	1·2	10·5	24·5	2·22	153	72·8
80	8·21	1·28	73·5	340	0·19	0·60	0·8	9·0	21·5	1·05	118	57·1
75	7·98	1·13	74·2	339	0·15	0·42	0·6	8·0	19·2	1·35	93	30·4
70	7·92	1·04	74·5	339	Trace	0·28	0·6	7·5	18·9	1·40	91	25·1
46	7·04	0·76	75·8	341	Trace	0·18	0·5	5·0	15·2	0·95	68	10·2

Energy values of protein, fat and carbohydrate taken as 4, 9 and 4 Cal./g. respectively.

with yeast and a variable amount of sugar, can be baked to form bread. The baking, carried out in ovens at 235°–245° C (450°–473° F.), converts some of the starch into soluble starch and dextrins; the latter are partly converted into a brown caramel which, with the decomposition products of protein, gives the crust its flavour and appearance.

NATIONAL FLOUR

Flour Extraction Rate	Moisture %	Protein %	Fat %	Carbo-hydrate %	Thiamine mg/100 g	Nicotinic Acid mg/100 g	Riboflavin mg/100 g	Calcium %	Iron mg/100 g	Phosphorus %
85 %	12 5	12 2	1 5	69 7	0 29	2 0	0 06	0 143	2 07	0 47
80 %	15 0	11 9	1 4	70 2	0 24	1 6	0 08	0 143	1 65	0 39
90 %	15 0	12 1	2 3	66 2	0 35	4 6	0 15	0 027	8 00	—
NATIONAL BREAD										
80 %	—	8 9	1 0	52 4	0 15	1 2	0 06	0 107	1 2	—
WHOLEMEAL BREAD										
90 %	—	8 8	1 7	48 0	0 25	3 3	0 11	0 020	2 2	—

THE BIOLOGICAL VALUE OF WHEAT FLOUR

The nutritive value of the protein in flour depends upon the proportion of amino-acids which can be utilized by the animal for those specific purposes which only amino-acids can fulfil. Since the amino-acid requirement of the body is influenced by physiological states such as growth and lactation, it is always necessary to define the circumstances under which the nutritive value of a protein has been measured The biological value of a protein is defined as the percentage of absorbed nitrogen which is retained by the body (Boas and Fixsen, 1934, Mitchell 1944; Block and Mitchell, 1946–47). Henry and Kon (1945) showed that the biological values of the protein in breads baked from flours of 100 per cent, 85 per cent, 80 per cent, and 70 per cent extraction were, 56 1, 53 2, 53 6 and 51 2 In considering this matter Kon and Henry (1945) found that the difference in the biological value between 70 and 85 per cent extraction flour is just significant; if, however, the values are recalculated in terms of nitrogen eaten, this difference disappears since the digestibility of the 85 per cent is slightly less than that of the

A detailed examination of Table 46 shows clearly the important relationship between the mineral and vitamin content of wheat and the degree of its extraction. Taking the content of wholemeal as 100, the loss in Manitoba flour of 85, 80, 75 and 70 per cent extraction is for thiamine, 22, 45, 75 and 81 per cent; for riboflavin, 41, 53, 59 and 59 per cent; and for calcium, 33, 44, 52 and 53 per cent respectively. The important differences in nutritive value between 100, 85 and 70 per cent extraction flours are in their content of thiamine, riboflavin, nicotinic acid, calcium and iron.

The Composition of National Flour and the National Loaf.—As a result of studies based on the microdissection of the wheat grain more information has been obtained concerning the content and distribution of nutrients in the wheat berry, particularly with regard to thiamine, riboflavin and nicotinic acid. It has become possible, by improved milling techniques, to make available an 80 per cent extraction flour containing more of the nutrients than was formerly possible and, by excluding more of the bran, to enable the public to have whiter bread of improved acceptability.

During the war national flour was examined for the Ministry of Food by the Research Association of British Flour Millers, St. Albans, and reports given at frequent intervals were published in *Nature*. Since 1946, however, this work has been carried out by the Department of the Government Chemist. In August 1950, the rate of extraction of national flour was reduced from 85 per cent to 81 per cent. This rate of extraction refers to flour produced by the mills from the grist supplied. For issue it is usually mixed with a proportion, 15–20 per cent, of imported white flour of about 70 per cent extraction, so that national flour *as delivered* is equivalent to 80 per cent extraction. Some indication is given of the rate of extraction by the percentage of fibre; the thiamine content is some measure of the inclusion of the germ in the milling. During the post-war years there has been a gradual and definite improvement in the quality of the flour as judged by the fibre average. The result of reducing the extraction rate from 85 per cent to 80 per cent was a slight loss of certain nutrients, about 10–20 [illegible] 51).

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[illegible] h and,

with yeast and a variable amount of sugar, can be baked to form bread The baking, carried out in ovens at 235°–245° C. (450°–473° F.), converts some of the starch into soluble starch and dextrins ; the latter are partly converted into a brown caramel which, with the decomposition products of protein, gives the crust its flavour and appearance

NATIONAL FLOUR

Flour Extraction Rate	Moisture %	Protein %	Fat %	Carbo-hydrate %	Thiamine mg /100 g	Nicotinic Acid mg /100 g	Riboflavin mg /100 g	Calcium %	Iron mg /100 g	Phosphorus %
85 %	12 5	12 2	1 5	69 7	0 29	2 0	0 06	0 143	2 07	0 47
80 %	15 0	11 9	1 4	70 2	0 24	1 6	0 08	0 143	1 65	0 39
90 %	15 0	12 1	2 3	66 2	0 35	4 6	0 15	0 027	3 00	—
NATIONAL BREAD										
80 %	—	8 9	1 0	52·4	0 15	1 2	0 06	0 107	1 2	—
WHOLEMEAL BREAD										
90 %	—	8 8	1 7	48 0	0 25	3 3	0·11	0 020	2 2	—

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The nutritive value of the protein in flour depends upon the proportion of amino-acids which can be utilized by the animal for those specific purposes which only amino-acids can fulfil. Since the amino-acid requirement of the body is influenced by physiological states such as growth and lactation, it is always necessary to define the circumstances under which the nutritive value of a protein has been measured. The biological value of a protein is defined as the percentage of absorbed nitrogen which is retained by the body (Boas and Fixsen, 1934 ; Mitchell 1944 ; Block and Mitchell, 1946–47). Henry and Kon (1945) showed that the biological values of the protein in breads baked from flours of 100 per cent, 85 per cent, 80 per cent, and 70 per cent extraction were, 56 1, 53 2, 53 6 and 51 2 In considering this matter Kon and Henry (1945) found that the difference in the biological value between 70 and 85 per cent extraction flour is just significant ; if, however, the values are recalculated in terms of nitrogen eaten, this difference disappears since the digestibility of the 85 per cent is slightly less than that of the

70 per cent extraction flour. The same conclusions were arrived at by Kosterlitz and Campbell (1946, 1948), who assayed the biological value of the proteins by their effect on the cytoplasm of the liver. A suggestive but not significant difference was found if the values were calculated in terms of the nitrogen eaten; if, however, the smaller digestibility of the 85 per cent extraction flour was taken into account the difference became just significant. By determining the rate of growth of rats and their retention of nitrogen, Chick *et al.* (1946) found a slight difference in the nutritive value of the proteins in favour of the higher extraction flours, but concluded that the differences in the amount and quality of proteins in flours of different extractions are only of importance under conditions of poverty or food scarcity when bread forms an unduly large proportion of the diet.

Further observations on the nutritive value of the proteins in wheat flours of different extraction rates have been made by Chick and Slack (1948). By determining the protein efficiency ratio (g. weight increase/g. protein consumed, called the P.E.R.) for the proteins of different flours they demonstrated an advantage over the proteins of white flour of 17–26 per cent for those of wholemeal flour and of 18–16 per cent for those of flours of 85 per cent extraction. The nutritive advantage shown by the proteins in flours of higher over those of lower percentage extraction is due to the fact that the proteins contained in the outer layers of the grain, which include the aleurone layer, are of better quality than those in the endosperm; they are richer in the essential amino-acids—lysine, arginine and tryptophan (Jones and Gersdorff, 1925; Barton-Wright and Moran, 1946). From the work of Chick and Slack it might be concluded that, for the support of growth as measured by the value of the P.E.R., the nutritive efficiency of the proteins of whole-wheat flour is about 20 per cent greater than that for the proteins of white flour (70 per cent extraction). The value of the proteins in 85 per cent extraction flour was found to be equal to that of the whole-wheat flour, while the value of the 80 per cent flour was much lower and approximated that of 70 per cent extraction flour. They also showed that the coefficients of apparent digestibility of the nitrogen in the flours of 70, 80, 85 and 100 per cent extraction were respectively 89, 86·7, 85·5 and 81 per cent and concluded that the lower digestibility of the nitrogen in the flours of higher extraction was more than compensated

by their greater nutritive value. According to McCance and Widdowson (1947) the difference in digestibility between 80 and 90 per cent extraction wheat, Manitoba and English, is 8 7 and 8 4 per cent respectively in favour of the lower extraction rate.

Agenized Flour.—The researches of Mellanby (1946), Moran (1947) and others have drawn attention to the possible harmful effects which may arise from eating bread baked from flour containing nitrogen trichloride or agene. It has been shown that a condition of canine hysteria can be produced by feeding dogs on a diet 70 per cent of the energy of which is obtained from flour treated with agene Before or after the attack, the dog may have epileptic-like seizures followed by unconsciousness and even death of the animal. These toxic effects are due to some alteration in the gluten of the flour by agene; they are not peculiar to gluten but may be produced in other proteins, for example, casein, by treatment with agene. The toxin is not destroyed by hydrolysis with proteolytic enzymes, which would indicate that one is not dealing with a deficiency disease but with a definite toxic factor produced by nitrogen trichloride. Tests carried out on monkeys and man have failed to show any untoward effects; results have been absolutely negative in cases where adults have been fed daily for 2 months, 360 grams of flour agenized at three times the normal level. Nevertheless, since so much of the energy of our diet is supplied by flour it was recommended by a Scientific Committee, representative of the Ministries of Food and Health, the Medical Research Council and the milling industries and convened by the Chief Medical Officer, Sir Wilson Jameson, that nitrogen trichloride as an improver substance should be replaced by chlorine dioxide (1950). It has been shown that the nutritive value of wheat gluten, determined in puppies or in adult dogs, was not altered by treating flour with [illegible] · cwt There was [illegible] ria or of abnormal cortical activity as shown by electroencephalograms (Allison *et al.*, 1950). The Government of the United States made the use of nitrogen trichloride, as a flour improver, illegal from 1st August 1949.

Phytic Acid in Cereals.—In order that bread should be as nutritious as possible during the war the rate of extraction

70 per cent extraction flour. The same conclusions were arrived at by Kosterlitz and Campbell (1946, 1948), who assayed the biological value of the proteins by their effect on the cytoplasm of the liver. A suggestive but not significant difference was found if the values were calculated in terms of the nitrogen eaten; if, however, the smaller digestibility of the 85 per cent extraction flour was taken into account the difference became just significant. By determining the rate of growth of rats and their retention of nitrogen, Chick *et al.* (1946) found a slight difference in the nutritive value of the proteins in favour of the higher extraction flours, but concluded that the differences in the amount and quality of proteins in flours of different extractions are only of importance under conditions of poverty or food scarcity when bread forms an unduly large proportion of the diet.

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insoluble salt and thus rendering it inactive, at least as far as calcium metabolism is concerned. It is clear that a diet adequate for the growth of bone and teeth must contain vitamin D, phosphorus and calcium, the last in sufficient amounts to prevent any deleterious action of the phytate of cereals. That the great mass of industrial workers in England during the eighteenth century had no such adequate diet was demonstrated by the prevalence of bone deformities and dental caries in children and adults. Where a cereal diet is associated with an adequate intake of calcium, for example, where oatmeal porridge is taken with sufficient quantities of milk, or fish and liver are largely eaten, the problem of defective bone formation does not arise. As a result of the recent war the Government adopted a policy whereby provision was made for the supply of free milk and vitamin A and D supplements to children and priorities to nursing mothers; this ensured calcium for the children. The lack of calcium, vitamins A and D due to the reduction in supplies of milk to non-priority groups, the increased extraction of wheat flour and the great diminution in butter were made good by the fortification of flour—7 oz. calcium carbonate to the 280 lb. sack in May 1942 and 14 oz. to the 280 lb. sack from August, 1946—and the supply of vitaminized margarine These gave approximately 300 mg. of calcium per day in the bread eaten and about 500 i.u. of vitamin A and 90 i u. of vitamin D per oz. of margarine.

Danish investigators (Hoff-Jørgensen *et al.*, 1946) consider diets rich in phytic acid and low in calcium to be undesirable and recommend the addition of calcium to, or the removal of phytic acid from, the bread of the country; the latter is easily accomplished where most of the bread is made from rye, since rye contains much phytase which under correct baking conditions hydrolyses the phytic acid. Some difference of opinion exists on the power of the intestinal ferments to hydrolyse phytic acid; according to McCance and Widdowson about 50 per cent of the phytate phosphorus is excreted, which indicates a rather poor hydrolysis; on the other hand, Cruickshank *et al.* (1945) found that when phytic acid was taken by ingesting 51 oz. of oatmeal [illegible]

to 1076 mg. per day. What is clear in all such experiments is

of wheat grain was raised from 70 to 85 and even to 90 per cent; this ensured a larger proportion of nutrients—protein, vitamins of the B group and minerals, particularly calcium, phosphorus and iron. However, such an increase in the extraction rate resulted also in an increase of phytic acid which is chiefly present in the germ and outer layers of the wheat berry; According to the work of Sir Edward Mellanby, McCance and Widdowson and others, phytic acid, a hexaphosphoric acid ester of inositol capable of forming calcium and magnesium salts (phytin), is in effect an anti-calcifying factor in oatmeal, wholemeal wheaten flour and, to a much less extent, in rice and white flour. Its activity in this respect is due to phytic acid in the cereal not being completely saturated with calcium and having therefore the property of binding calcium during digestion in the intestine and rendering it unavailable to the body. Such an action may retard the growth-promoting effect of the cereal; it does interfere with calcium metabolism in the presence of a deficiency of vitamin D, leading to rickets in the rapidly growing young animal and to decalcification in the adult body (osteomalacia). In this connection one should not be obsessed with the element calcium but should give a balanced attention to all the factors necessary for the growth of strong bones and hard teeth. Sir Edward Mellanby puts the matter clearly in saying: "It is impossible to study the calcification of bone in growing animals without being impressed by the dominant position held by vitamin D. Take all the vitamin D away from the food and ultimately, when the reserves of this substance are lost, the animal cannot retain sufficient calcium however much is added to the food." Vitamin D stimulates the absorption of calcium from the intestine and plays an important part in the deposition of a calcium-phosphorus compound in the osteoid tissue of the growing bone; it also stimulates the hydrolysis of phytate (the Ca : Mg salt of phytic acid) in the intestine, thus liberating phosphorus from the phytate in the cereal. How vitamin D breaks up the phytate or initiates calcium absorption is unknown; the matter for all practical purposes becomes one of controlling the activity of the phytate ingested with the food and, curiously enough, it is by the use of calcium that this can best be done. Phytic acid removes calcium; calcium if given in adequate amount can saturate the phytic acid, leading to its precipitation as an

Can a relatively white loaf of good quality be made from flour finely ground and containing the highest possible amount of the essential nutrients? The reduction, late in 1950, of the extraction rate of flour from 85 to 80 per cent has been achieved without any appreciable loss in vitamin B_1, nicotinic acid and iron; the flour containing 8 per cent less bran, has proved very satisfactory in colour and nutritional value to the scientists and others responsible for its production. Present knowledge merely renews the challenge to further achievement in science and technology.

THE BREAD CONTROVERSY (1940–44)

In view of our knowledge of the nutritive value of flours of various rates of extraction previous to the war (1939–45), and of the advances in scientific research and milling techniques since the war, the following brief account of the opinions expressed on a very topical subject may be of some interest.

The bread controversy during the world war, 1939–45, was based on the question, "From what type of flour should our bread be made—white flour, white flour enriched, or 85 per cent extraction flour?"

To those who can secure in their diets an adequate supply [illegible]

protective foods white bread is of the nature of a disaster in the [illegible]

article made from stone ground flour, caused revolt and war in a non-industrial age, one can well imagine what might have happened if industrial advance, which produced roller mills, had not also made possible a wider and better distribution of animal foods. The social and economic history of the nineteenth century reveals the appalling results in human lives wherever roller milled flour was not associated with a sufficiency of the animal foods. *It is a curious fact that the problems of peace, which would jeopardize the life of a nation at war, are energetically faced and often solved when the dire emergency arises.* In view of the great lack of "protective foods" during the war,

that the range of digestibility of phytate in the human alimentary tract is large, and if phytic acid is regarded as deleterious its activities should not be taken lightly but counter-acted by taking calcium and vitamin D at the same meal at which the *phytate-containing cereal is ingested; the best remedy, containing calcium and vitamin D, is milk.*

Conclusion.—That the higher extraction flour would lead to a greater indigestibility of the loaf and cause a *significant loss* in both quantity and quality of protein available for human consumption is not founded on fact. As a result of the experiments of Krebs and Mellanby (1942), McCance and Widdowson (1947), Chick and Slack (1948), it may be accepted that there is little difference between the digestibility of protein and the utilization of calories of 75 and 85 per cent extraction flour.

In discussing this question it is rather beside the point to state, as an argument in favour of white bread, that the baking of the national wheatmeal loaf, resulting in a loss of offal for the feeding of cows, means a reduction in the production of milk. The whole controversial question of the nutritive value of bread must be settled on its own merits. There need be no lack of offal for the feeding of cattle in peace-time; for the requirements of cows should place no obstacles in the way of milling even 90 per cent extraction flour for human consumption, provided adequate quantities of maize and protein cake are imported.

It would appear that we are now in the position where the application of scientific knowledge awaits further developments in milling techniques. To secure a flour of good nutritive value all the germ—certainly all the scutellum—and as much as possible of the outer endosperm and aleurone layers adjacent to the bran, must be retained in the final product of milling. As new milling methods are devised, more of these essential parts of the grain will appear in an 80 per cent extracted flour. The public should not forget that to retain the germ and the outer endosperm and at the same time reject just that amount of the bran to give a good and acceptable colour, requires a good deal of inventive skill on the part of the milling engineer.

It should no longer be a question of wholemeal bread versus white bread, nor of wholemeal versus enriched white flour, but, in view of the disastrous effects of white bread on generations of our people and the absurdity of removing essentials and returning but a few of their equivalents, the question should now be,

been decided to fortify white flour with vitamin B_1 and calcium The proposition was supported by Sir Jack Drummond and Dr. Moran, who maintained that " the introduction of the new white flour will undoubtedly stultify the controversy of white versus brown bread ". The leading article in the *Lancet* of 27th July 1940 stated : " Modern scientific investigation of nutrition has made it full clear that wholemeal bread is a more nourishing food than white bread and that it would be better for the nation's health to eat brown bread ". Suggesting that this was sufficient reason for changing from white to brown, bread, the " Leader " continued ; " the question is more complicated than this for people do not like brown bread, pigs and poultry do like and need the bran and germ which form the milling offals when white flour is milled ; brown flour does not keep ; brown bread needs much more yeast to bake it than white ; brown bread has usually been dearer than white ". It is true that people do not like brown bread unless it is well made : it is also true that pigs like and need the germ, but so do children and other human beings. But enriched or fortified bread became the order of the day. True, the white bread eaters were not yet deprived of their staple luxury, but who could regard white flour fortified with vitamin B_1 and calcium carbonate as in any way equivalent to whole wheat flour ? That there were doubts in the scientific mind concerning the replacement of whole wheat flour by a fortified substitute was evident when the Accessory Food Factors Committee of the Lister Institute and Medical Research Council (London) issued a memorandum on Bread in July 1940, in which they recommended that :

" I. Flour for the bread of the people should contain the germ of the wheat grain, as much as possible of the aleurone layer, and the finer portions of the bran. Instead of flour consisting of about 70 per cent of the wheat grain, as it does at present (1940), the percentage extraction should be at least 80 to 85 per cent.

" II. Bleaching or improving of flour by oxidizing agents or any process which damages the nutritive value of the flour should be prohibited.

" III. The public would be benefited by the addition of calcium salts to the flour from which bread is made. Bread

the Government undertook the responsibility of feeding th nation. By securing for the people through rationing a fa distribution, at a controlled price, of essential foods and by con cerning themselves with the nutritive quality of the people' bread, the Government in war time *virtually* solved a peace-tim problem. That the problems of food distribution and th technique of baking a highly nutritious loaf from fine flou containing all the nutrients of the wholemeal have been entirel solved, bears no immediate admission; that they can be solve none should deny.

During the first world war the nutritional value and palata bility of "war" bread was investigated by Sir Frederic Hopkins (Cambridge), Professor Noel Paton (Glasgow) and Dr J. A. Gardner (London) on behalf of the Food (War) Committe of the Royal Society. The war bread was not generally accepte by the people, the chief reasons being the unpalatability o badly baked bread. With better knowledge, better brea could have been made and the nutritive superiority of an 85 to 90 per cent extraction flour would have been more generally recognized. From this experience one outstanding fact emerged, namely, that scientific knowledge must be more closely related to technical development. Since 1920 research has shown the value of cereals as a source of protein, the important rôle of the proteins of milk, meat, fish and even fruit in supplementing the proteins of the whole grain, the interplay of vitamins, mineral salts and carbohydrates in the biochemistry of living processes, and the effect of rancidity and staleness on various nutrients such as fat soluble vitamins. In a word, the experiment with bread in the latter part of the first world war, based on scientific advice, was receiving further scientific support. It was no matter for surprise that the whole question of a more wholesome bread should be revived. It may, in view of the knowledge at our disposal, be a matter of surprise that the subject should attain the status of an acute political question. Controversy, not without acrimony, coloured much of the *pros* and *cons* of the arguments setting forth views on the question ...nce, prejudice and

...nentary *Secretary* to the Ministry of Food, announced in the House of Commons that, on the advice of the Scientific Food Committee, it had

vitamin B_1 and calcium carbonate (7 oz. to the 280 lb sack of white flour and 14 oz. to the 280 lb. of 85 per cent extracted flour) One year afterwards (May 1941) the bakers had still not received flour from the millers containing either vitamin B_1 or calcium, but the Government had adopted the first recommendation of the Medical Research Council, for Lord Woolton announced in the House of Lords that in view of the unanimity of scientific opinion, the Government had decided to make national wheatmeal bread available to the public at the price of white bread. The national loaf, baked from 85 per cent extraction flour, but with no addition of calcium, had arrived.

When white flour is milled to, say, 75 per cent, 25 parts go to feed animal stock; with 85 per cent extraction, 15 parts go to the farms and the human consumer secures 10 more parts out of the 25 parts rejected and used as wheat offals or " wheat feed " for animals. The important point was to select the best 10 out of the 25 parts usually discarded as offal, and in the selection several factors were considered, namely, nutritive excellence, palatability, æsthetic appearance, digestibility, roughage or fibre content. Following upon such considerations the Medical Research Council issued a second memorandum defining the character of the wheatmeal recommended (31st May 1941). Table 48 gives the two suggested flours: No. 1 was selected *because it contained the highest vitamin* B_1 *content, closely* approaching the wholemeal flour value, the fibre content was comparatively low and its appearance was pale brown and the bread made from it most closely resembled white bread in flavour, texture and colour.

The analyses of the flours are shown in the Table.

TABLE 48

Flour, per cent extraction	Fibre, per cent	Ash, per cent	Protein, per cent	Vit B_1, I U per g	Calcium, mg 100 g	Phosphorus, mg/100 g	
						Total	As Phytic Acid
I 85	0 6	0 90	11 4	1 20	27	203	123
II 85	0 85	0 94	11 5	1 15	27	211	128
White 73	0-0 2	0 46	10 6	0 85	15	101	35
Wholemeal 100	1 8	1 51	11 9	1 40	36	343	246

made from flour thus supplemented should be specially designated. The production and consumption of milk, cheese and vegetables should at the same time be promoted to the maximum extent, in order to secure an adequate supply of calcium.

"IV. *The use of baking powders, which produce alkaline* conditions, should be strongly discouraged in making bread and biscuits."

The report emphasized the following points with regard to vitamins: (*a*) that the normal sedentary adult required *300* i.u. of vitamin B_1 (thiamine) and that a 1 lb. loaf *made of* flour of 70 per cent extraction would give 80 to 160 i.u. vitamin B_1, while that made from 80 to 85 per cent extraction flour would give 300 to 450 i.u. vitamin B_1; (*b*) that the change to 80 or 85 per cent extraction flour would benefit adults and children of all *classes*; (*c*) that the *amount of* vitamin B_2 (riboflavin) would also be greater in the brown flour; (*d*) that 80 to 85 per cent extraction flour would, by *including the germ*, substantially increase the quantity of vitamin E.

With regard to minerals, it was stated that the human daily requirement of iron may be taken as 10 mg., that a 1 lb. loaf made of 70 per cent flour would supply 5 mg., that made from 80 to 85 per cent extraction flour would supply 10 mg. Calcium as a dietary constituent must be considered in relation to the amount of phytic acid in the particular cereal. In this respect 85 per cent extraction flour contains more phytic acid than the 70 per cent extraction and therefore is not regarded as a good source of calcium, since in the presence of large quantities of phytic acid the metabolism of calcium and phosphorus is impaired. For this reason the Committee suggested the addition of calcium carbonate and also emphasized the importance of *milk, cheese and vegetables.* Another possible disadvantage of bread made from a high extraction flour was the reduction in utilization of the nutrients. The report stated, and it is an important fact, that reduced utilization is due to the coarseness of the branny particles and suggested that, if a 90 or even 100 per cent extraction flour could be obtained in a finely ground and homogeneous condition, its nutritive advantages would be still further enhanced and the disadvantages of incomplete utilization would tend to disappear.

The response of Authority to this recommendation is interesting, for the Government decided to fortify white flour with

up to 15 per cent bran with white flour and still meet the requirements of the Ministry of Food. To add bran to white flour in order to make it equal 85 per cent extraction flour is not the way to make the best selection of the essential nutrients in the wheat berry. The criteria for milling was that the flour should contain 1 i.u. of vitamin B_1 per gram and less than 0 9 per cent fibre. The bran was responsible for the dark colour, coarse texture and, to some, the unpalatability of the national loaf. The loaf steadily lost favour. In the *Lancet's* leading article, 15th November 1941, it was affirmed that, "In this conflict between the national and individual interests, the millers have thus won the day and a golden opportunity of furthering the health of the people has been lost".

On the 11th March 1942, the controversy was temporarily suspended when Lord Woolton announced in the House of Lords: "H M. Government have decided to increase to 85 per cent the ratio of flour from milled wheat in this country. This means we shall stop the production of white bread." Lord Horder, adviser on medical matters to the Ministry of Food, welcomed the decision, saying that he and his colleagues "are uniformly of the opinion that no single step which the Government could have taken in respect of the nation's food is so calculated as this one to raise the level of the nation's nutrition". "The national wheatmeal bread would be suitable in all forms of illness in which bread is allowed and it would be of greater benefit to those who are still living below the poverty line, for they are the slowest to change old habits in the matter of basic foods" "The victory of science, approved by the highest medical authority, was undoubtedly gained since it had an economic ally in shipping" In commenting

it. Why, then, should it be thought praiseworthy to remove from the wheat berry the valuable minerals and vitamins which it contains?" The national loaf became compulsory on 23rd March 1942.

In October 1944 the extraction of wheat was reduced to 82½ per cent. The first reaction to this was that to reduce the extraction of flour, even if synthetic vitamins were to be added, was a further questionable procedure. It is always wise to

Of the national loaf made from No. I, 85 per cent extraction flour, the leading article in the *Lancet* for 31st May 1941 said: "Few people grasped that the national loaf is probably the best bread, judged on its food value, that they have ever eaten, for it has been selected after a most careful scrutiny of the nutritive value of the different parts of the wheat grain". The protagonists of enriched flour would not accept this, saying that the 85 per cent extraction would sharply reduce milk supplies as a result of the loss of wheat offal for cattle feeding; there would be a net loss of nutrients and the bread would not be acceptable to the public. The controversy still raged and more rats were fed on diets containing fortified white flour and whole wheat flour. However valuable as an experimental subject a rat may be, and it is most valuable, a rat is not a human being. While the findings on rats can never be entirely accepted as applicable to man they have certainly indicated fruitful lines of study of problems as they may affect man. It is known that breads made from higher extraction flour have a depressing effect on the assimilation of calcium. The depression is of the order of 10 per cent (Henry and Kon, 1945) Despite this slight depressing effect the superior growth of animals receiving wholemeal bread was admitted by many investigators (Chick, 1942; Copping, 1943; Henry and Kon, 1945). It is also true that there is a lower incidence of rickets where whole grain bread is consumed. In baking whole grain bread the phytic acid is in a great measure destroyed by the phytase present in the flour (Mellanby, 1944). It is probably correct that where wholemeal bread supplies 40 to 50 per cent of the daily Calories—i e. about 1 lb. of bread per day = 1200 Calories—the absorption of calcium is depressed (McCance and Widdowson, 1942).

Other pertinent questions arose, one being, "Why was the national wheatmeal loaf so unacceptable?" There were many answers to this question. In a war-time Social Survey made between February 1942 and October 1943 by Miss G. Wagner, it was found that 52 per cent of 2530 housewives questioned approved of the national wheatmeal loaf, 35 per cent criticized and disapproved entirely, while 13 per cent had no opinion upon the matter. Probably the main cause behind all criticism was a lack of uniformity in the national wheatmeal flour, due to the permission given to millers to mix

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assume that what has been discarded in milling cannot be fully replaced by the addition of a few essential nutrients, for the simple reason that we have not yet a complete knowledge of the function of what has been discarded. Fortification of white flour was not wholly favoured by Canadian medical men and scientists, who maintained that the wheat should be so milled that the protein, minerals and vitamins would be retained in the flour. Some interesting experiments in milling the wheat berry were carried out in Canada. Using the vitamin B_1 content as an index of the nutritive quality of the flour obtained, Canadian scientists found that if the moisture content of the wheat milled was reduced from 15·5 to 12·5 per cent, the flour of 75 per cent extraction contained 363 i.u. vitamin B_1 per pound as compared with 254 i.u. in the white flour obtained by milling wheat with 15·5 per cent moisture. The changes in extraction rate to which reference has been made, were officially put into effect as follows: 85 per cent in March 1942, enforced largely because of the acute shipping shortage; in the winter 1942–43 the 85 per cent extracted flour had added to it a little barley, rye and oats: in November 1943 the extraction rate was reduced to 82·5 per cent and in October 1944 to 80 per cent: in February the extraction rate was increased to 85 per cent during the period of bread rationing and reached 90 per cent for a short time during that period: in May 1946 the calcium carbonate was increased to 14 oz. per 280 lb. sack of flour: in August 1950 the extraction rate was reduced to 80 per cent, at which point it is likely to remain for some time. (See p. 222.)

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of fat. In the winter and spring the vitamin A content may be as low as 10 to 20 i.u. per gram of fat. A noteworthy point is that, while the yellowness of cream is of no value in comparing milks from different breeds of cow, it is of value in comparing the milk from any particular breed. That Jersey and Guernsey

TABLE 49

NUTRIENTS OF MILK, BUTTER, MARGARINE AND CHEESE

From *Nutritive Values of War-time Foods*, H.M S O. London, 1945

Contents per 100 grams

Food	Protein	Fat	Carbohydrate	Calories	Calcium	Iron	Vitamin A	Vitamin B_1
	g.	g	g.		mg	mg	I U	µg
Milk, human (1)	1 4	4 7	6 9	77	29 0	(0 03)	137	14
Milk, fresh, whole, May to Nov (2)	3 3	3 6	4 4	63	120	0 1	140	45
Milk, fresh, whole, Dec to April . . .	3 3	3 6	4 4	63	120	0 1	70	45
Milk, skimmed .	3 4	0 1	4 6	33	124	0 1	0	45
Milk, condensed, whole, sweetened, U K .	8 2	9 2	49 6	314	290	0 2	370	105
Milk, condensed, whole, unsweetened, U K (3) .	8 5	9 2	11 5	163	294	0 2	370	65
Milk, skimmed, sweetened	9 5	0 5	55 8	266	320	0 3	20	125
Milk, powder, whole . .	25 6	26 7	35 6	485	805	0 8	1070	300
Milk, powder, skimmed .	35 8	0 7	47 9	341	1225	1 0	30	390
Butter, Empire, imported	0 5	82 5	0	745	15	0 1	4000	0
Cheese, Cheddar type	24 9	34 5	0	410	810	0 6	1300	30
Margarine, vitaminized	0	85 3	0	768	4	0 3	2000	0

(1) Kon, S. K. and Mawson, E. H (1950).
(2) Riboflavin 150 µg. Nicotinic acid 80 µg Pantothenic acid 250 µg. Ascorbic acid 1 5 mg
(3) Known also as evaporated milk

cows produce milk the cream of which is so yellow, is due to their inability to convert carotene, which gives the colour, into vitamin A. Good feeding and care of milch cows is always repaid by a milk of high fat content, be they Jerseys or Ayrshires (Davies, 1944).

Milk is not to be regarded as a good source of vitamin C. Two factors are at play in the destruction of vitamin C in milk; they are oxygen and sunlight, for sunlight is responsible for

CHAPTER XIII

MILK

The Nutritive Value of Milk.—Investigations of the chemical composition and nutritive value of milk and milk products and of the best means for their production for human use have been actively promoted for many years at Research Institutes, Marketing Boards and Veterinary Colleges in England and Scotland. The nutritive value of milk lies in the high biological value of its protein, its rich store of mineral salts, particularly calcium and phosphorus, and its substantial content of vitamins A and B_1, B_6, riboflavin and nicotinic acid (Table 48). Milk is excellently adapted to the needs of the growing animal. Reference has already been made to the relation of the protein and mineral salt content of the maternal milk to the rate of growth in various animals. Its value as a food for children is indicated by the fact that, of the recommended daily dietary allowance of a 5-year-old child, 1 pint of summer milk supplies 75 per cent of riboflavin, 70 per cent of calcium, 88 per cent of protein, approximately 35 per cent of vitamins A and B_1 and 25 per cent of the Calories. Milk is the adult's best source of calcium, 1 pint contributing almost 88 per cent of the recommended daily requirement; of protein it supplies about 28 per cent and of riboflavin about 35 per cent (Kon, 1944). One pint of milk gives 350 to 380 Calories, the figure varying with the fat content of the milk. While cow's milk is not the perfect food for the human infant, it forms the best foundation of the diet of infants, children and adolescents. Its fat is present in a finely divided or emulsified state and is thus easily assimilated; its sugar, lactose or milk sugar, does not cause fermentative disturbances as other sugars may do. The Calorie value of milk is higher for the milk of the high fat breeds of cattle, Jerseys and Guernseys, than it is for the milk of Shorthorns, Ayrshires or Friesians. The feeding of cows is of special importance for upon it depends the richness of the vitamin A content of the milk. When grass and kale are abundant, as they are in the summer and autumn, milk is particularly rich in vitamin A, containing from 30 to 40 i.u. of the vitamin per gram

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	g	g.	g		mg	mg	I U.	µg.
Milk, human (1)	1 4	4 7	6 9	77	29 0	(0 03)	137	14
Milk, fresh, whole, May to Nov. (2)	3 3	3 6	4 4	63	120	0 1	140	45
Milk, fresh, whole, Dec. to April	3 3	3 6	4 4	63	120	0 1	70	45
Milk, skimmed	3 4	0 1	4 6	33	124	0 1	0	45
Milk, condensed, whole, sweetened, U K	8 2	9 2	49 6	314	290	0 2	370	105
Milk, condensed, whole, unsweetened, U K. (3)	8 5	9 2	11 5	163	294	0 2	370	65
Milk, skimmed, sweetened	9 5	0 5	55 8	266	820	0 3	20	125
Milk, powder, whole	25 6	26 7	35 6	485	895	0 8	1070	300
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of watercress was given daily to one experimental group. Figure 44 shows graphically the results obtained. These results are important, emphasizing, as they do, the value of fat soluble vitamins and calcium in the diet, and the importance of at least 1 pint of fresh liquid milk in the daily diets of growing boys and girls.

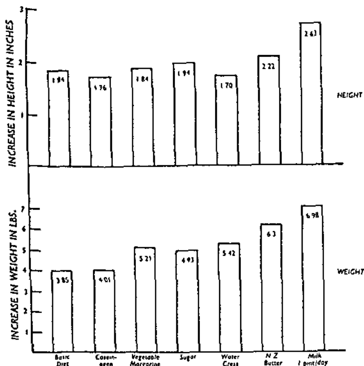


FIG 44 —Diagrammatic presentation of increase in height and weight of boys in one year on various supplements to a basic diet [*Drawn from data of Dr H C. Corry Mann, O B.E*]

The nutritional value of milk was heavily stressed 15 years ago in the first report of the Advisory Committee on Nutrition (Ministry of Health) "Within recent years", to quote from the Report, "much experimental evidence has been brought forward which has shown that cows' milk is the most valuable food known for the promotion of growth and health in children." At that time, 1935, the calculated consumption

the photochemical oxidation of vitamin C. The loss of vitamin C may be prevented by the removal of oxygen from the milk or by preventing the milk from being exposed to sunlight. The latter may be achieved by the delivery of milk in brown bottles or in cartons. The use of cartons would not only be of value in preserving vitamin C but would overcome one of the greatest difficulties in providing safe milk, namely the effective sterilisation of bottles.

The amount of vitamin D in milk is very small; most of it is derived from the action of sunlight on the cow's hide The lack of vitamins C and D in milk can readily be made good in infant feeding by the addition of orange juice and cod-liver oil to the diet. In the U.S.A. great steps have been made in the enrichment of cow's milk by irradiation of the milk, addition of vitamin D concentrates to the milk, or feeding cows with irradiated yeast.

The Value of Milk in the Feeding of Children.—It has been established that "children from three to thirteen years of age should receive two pints of milk per day to ensure full growth and development". Sherman, an American authority, has said that "milk greatly favours growth and development in youth, confers health and vigour throughout adult life and postpones old age. In no other way can the food habits now prevailing, especially in our cities, be so certainly and economically improved as by a more liberal use of good milk".

One of the most convincing experiments on the value of milk for growing children was that carried out by Dr. Corry Mann in 1926. Several groups of boys, aged 7 to 11 years, were the subject of the experiment. One group was given the regular diet of the institute in which these boys lived; the others had supplements, and the results in terms of changes in height and weight over 1 year were noted (see Fig. 44). It was found that an increase in growth, as measured by height and weight, was produced by the addition of 1 pint of pasteurised whole milk per day. No effect on height was produced by the addition of caseinogen in amount equivalent to that contained in the milk, or of unvitaminized margarine in amount equivalent to the extra Calories supplied by the pint of milk. With New Zealand butter in amount equivalent to the extra Calories, improvement was noticed. The sugar given was the equivalent in Calories of 1 pint of milk. Three-quarters of an ounce

Table 50 shows the incidence of pulmonary and non-pulmonary tuberculosis in England and Wales and Scotland from 1938 to 1948 The year 1941, with a total of 32,557 deaths showed an increase upon the number recorded for 1937, namely, 32,192; these figures gave cause for concern and led to the introduction of schemes, such as improved hospital accommodation and mass radiography, for a more decisive attack upon this disturbing problem in public health. In view of the fact that about

TABLE 50

TUBERCULOSIS DEATHS FOR 1938, 1941, 1945, 1947, 1948

(Excluding non-civilian males after 3rd September, 1939, and females after 1st June, 1941)

	ENGLAND & WALES		SCOTLAND	
Year	Respiratory (Pulmonary)	Non respiratory (Non-pulmonary)	Respiratory (Pulmonary)	Non respiratory (Non pulmonary)
1938	21,282	4,257	2,581	851
1941	23,339	4,934	3,116	1,058
1945	19,608	3,796	—	—
1947	19,753 (466)	3,322 (79)	3,390 (679)	705 (132)
1948	18,798	2,867	—	—

[illegible]

43,502,000
Total population of Scotland in 1938—4,993,000; 1948—5,201,000

35 per cent of milch cows in this country are tubercular and that milk production has been greatly increased, medical authorities have made repeated investigations of the incidence of human and bovine tuberculosis in the United Kingdom The human type is derived from man, infection being mainly by way of the respiratory organs; the bovine type is caused by drinking milk, contact with cattle and breathing the dust-infected air of byres Both types of infection are responsible for pulmonary and non-pulmonary forms of the disease Man, milk and cattle, in different degrees, are responsible for the transmission of tuberculosis. To differentiate between human and bovine

of liquid milk in this country was just under 0 4 pint per head per day, an average figure which is less revealing than the figures indicating the range of consumption. According to Lord Boyd-Orr, the lowest income group in his 1935 survey consumed 1·1 pints, the highest approximately 5·4 pints per head per week, the average being 3·1 pints per head per week, i.e. 0·44 pints per head per day. These and other facts stirred the Ministry

schemes

mothers

duction increased by 30 per cent and liquid consumption by 55 per cent. Since the beginning of the 1939–45 war, and as part of the policy of the Ministry of Food, a great improvement in milk distribution has taken place. Up to 1946 the National Milk and Milk in Schools Schemes provided one-third of a pint of milk at the cost of ½d. for all school children who cared to avail themselves of it, and 1 pint of milk daily for all nursing mothers, and children under 5 years of age, either free or at a reduced price; since 1946 all school milk has been free of cost. These two schemes to-day account for about 15 per cent of the total liquid milk consumption. In the interests of national health, these schemes should never be allowed to lapse. In view of the activity of the Ministries of Food, Health and Agriculture, and the milk propaganda campaigns, it is not surprising that the increase in liquid milk consumption from 1939 to 1944

the population per day, with provision within this average for the adequate supply of milk to expectant and nursing mothers, children and old people.

MILK AND TUBERCULOSIS

During the war it was found that the incidence of the most common infectious diseases declined rapidly but tuberculosis did not. While considerable attention has been given to the high mortality rate from tuberculosis in this country, it is still true that the non-pulmonary form of the disease tends to be overshadowed by the attention paid to human pulmonary tuberculosis. The non-pulmonary form causes much sickness, deformity and chronic invalidism.

still about 10 per cent of schools in England and Wales which are provided with potentially dangerous milk. The danger of unpasteurised milk is emphasized by the fact that while the greatest number of bovine infections is found in infancy and early childhood, 30 per cent of all cases of bovine infection were persons over 15 years of age (Table 52). A significant finding was that 87 per cent of those infected with the bovine type of tuberculosis gave a history of drinking raw milk as against 53 per cent of those infected with the human type.

Table 52

DISTRIBUTION OF HUMAN AND BOVINE TYPES ACCORDING TO AGE OF PATIENT AND SITE OF DISEASE

(Report to Medical Research Council of Investigation undertaken during the years 1943 to 1945)

Site of Disease	Age of Patient										Bovine (per cent)
	0–5 years		5–10 years		10–15 years		15 years and over		All Ages		
	H	B	H	B	H	B	H	B	H	B	
Meningitis	80	32	31	17	14	8	57	19	182	71	28 1
Cervical glands	11	39	15	39	13	19	49	20	88	117	57 1
Bone and joint	28	8	29	10	26	3	312	26	395	47	10 6
Abdominal	2	4	—	2	—	3	4	2	6	11	64 7
Genito-urinary	—	—	—	—	1	1	30	7	31	8	20 5
Miscellaneous	9	—	—	—	2	1	18	3	29	4	12 1
All sites	130	83	75	68	56	30	470	77	731	258	26 1
Bovine (per cent)	39 0		47 6		34 9		14 1		26 1		

H = human, B = bovine

A similar investigation was made on 112 patients in Wales. It was found that the incidence of the bovine type of tuberculosis was 17 per cent, the human type, 83 per cent. From the figures for England and Wales it is seen that about 24 per cent of all cases of non-pulmonary tuberculosis were due to infection with the bovine type of tubercle bacillus; in 1944, 1350 persons died from non-pulmonary tuberculosis of bovine origin. In the report it was clearly submitted that none of these deaths would have occurred if the milk supply had been adequately pasteurised. A similar investigation was made in Scotland, the results of which have not yet been published. In 1943–44

tuberculosis, *pulmonary and non-pulmonary*, *is therefore* a matter of considerable importance. The number of deaths due to bovine tuberculosis is arrived at by laboratory methods since it is not possible to distinguish clinically between the two types.

Non-Pulmonary Tuberculosis.—Table 51, which shows the chief sites of infection of non-pulmonary tuberculosis in the human body, clearly indicates that, while the number of deaths from this form is much smaller than that occasioned by pulmonary infection, the possibilities of structural disability and chronic ill health are much greater than the number of deaths would suggest. A report on non-pulmonary tuberculosis in

TABLE 51

NUMBER OF NON-PULMONARY TUBERCULOSIS DEATHS FOR 1921, 1938, AND 1947

Year	Central Nervous System	Intestinal and Peritoneal Tuberculosis	Spinal Tuberculosis	Tuberculosis of Bones and Joints	Tuberculous Glands	Total Deaths from Non-pulmonary T.B.	Death-rate per million of Population
England and Wales							
1921	—	2,147	667	417	123	3,354	68
1938	1,791	740	369	228	44	4,257	89
1947	1,533	445	252	115	58	3,822	79
Scotland							
1947	—	83	44	16	7	705	132

England and Wales made in 1949 by a Committee of the Medical Research Council under Professor G. S. Wilson stated that in 994 cases of non-pulmonary tuberculosis in England, 73·7 per cent of the patients were infected with the human and 26·3 per cent with the *bovine type of tuberculosis. An analysis* of the figures showed that the bovine type of bacillus was responsible for approximately 28 per cent of all cases of meningitis, 57 per cent of cases of cervical glandular tuberculosis, 10 per cent of cases of bone and joint disease and 20 per cent of cases of genito-urinary disease. *In all these groups the proportion of* bovine-type *infections* was *higher in children than* in adults. The pasteurisation of milk for infant feeding and for the school services has certainly lessened the risk of infection, but there are

The regional distribution is probably due to the fact that in the N.E. of Scotland, particularly in Aberdeenshire, the incidence of tuberculosis in cattle is high, and the high incidence in humans which is entirely rural, may be due to direct respiratory infection of men attending cattle, which, because of the more rigorous winter conditions, are kept in byres for a longer period than is usual in the southern parts of the country.

TABLE 53

CALCULATED NUMBER OF DEATHS IN ENGLAND AND WALES AND SCOTLAND IN 1937, DUE TO INFECTION WITH THE BOVINE TYPE OF TUBERCLE BACILLUS, ALL AGES.

(From G S Wilson, *The Pasteurisation of Milk*, 1942.)

	England			Scotland		
	Total Deaths	Bovine Deaths	Per cent Bovine	Total Deaths	Bovine Deaths	Per cent Bovine
Respiratory	23,970	336	1 4	2,791	151	5 4
Central nervous system	1,796	421	23 4	374	103	27 2
Intestines, peritoneum	676	554	82	159	92	50 7
Bones and joints	569	135	23	83	19	23
Lymphatic system, bronchial and glands, etc	432	92	21	57	17	30
Disseminated	1,086	65	6	199	22	11
	28,529	1,603	5 6	3,663	404	11 0

Total for U.K —deaths	= 32,192	Total bovine deaths	= 2,007
Bovine deaths	= 2,007	Total bovine respiratory deaths, i e pulmonary T B of bovine origin	= 487
Percentage bovine	= 6 2	Pulmonary bovine T B as percentage of total bovine T B deaths	= 24

This is borne out by the statement of Cutbill and Lynn (1944) who found 1·6 per cent of bovine-type infection in 2004 cases of phthisis which had not been in contact with cattle, compared with 16 4 per cent in 97 cases of phthisis which had been in contact with cattle. This emphasizes the possibility of the respiratory transfer of the bovine bacillus from cattle to man. The importance of direct inhalation infection with the

an investigation was carried out in Scotland by Professor Blacklock on surgical tuberculosis of bovine origin. He found that 13 per cent of the town cases and 31·6 per cent of the country cases were infected with bovine strains. The proportion of bovine infections was almost 3 times higher in the rural areas as compared with the urban. The cause of the higher incidence of bovine infections in rural as compared with urban areas depends upon many factors, the most important of which is the milk supply. In Scotland the number of attested herds is high, there being 4138 such herds in existence in 1944, and 13,518 in 1950, representing increases of 50 and 400 per cent respectively since 1939. In the towns the milk supply is largely in the hands of the big dairy companies which together with the Milk Marketing Boards adopt a high standard for safe milk and use heat treatment extensively. In rural areas, however, where the volume of milk is small and where, in the absence of efficient heat treatment, the consumer is liable to receive large doses of any infecting organism, the danger from the bovine type of tuberculosis is naturally greater. In the large cities of Scotland it was found that 20 1 per cent of purely tuberculous surgical conditions (glandular, bone and joint, genito-urinary and abdominal tuberculosis) were of bovine origin while in the rural areas the figure was 45·4 per cent.

Pulmonary Tuberculosis.—While pulmonary tuberculosis is chiefly of the human type, it has been shown that a certain amount is of bovine origin. Table 53 shows that in 1937, out of 2007 " bovine " deaths, 487 were of the pulmonary type, i.e. 24 per cent; of 26,761 respiratory deaths the percentage due to bovine bacilli was 1 9. The incidence of bovine pulmonary tuberculosis has a very unequal distribution throughout the country. The latest figures for the *incidence and distribution* of bovine pulmonary T.B. have been supplied by Professor G. S. Wilson (December 1950) and are as follows:

District	Number of human sputums examined	Bovine Bacillus isolated
England, South Wales	989	0 60 per cent.
Wales	201	1 00 "
England, North and Midlands	3,219	2 00 "
Scotland, excluding North-East	1,797	5 10 "
Scotland, North-East	972	7 00 "

The regional distribution is probably due to the fact that in the N.E. of Scotland, particularly in Aberdeenshire, the incidence of tuberculosis in cattle is high, and the high incidence in humans which is entirely rural, may be due to direct respiratory infection of men attending cattle, which, because of the more rigorous winter conditions, are kept in byres for a longer period than is usual in the southern parts of the country.

Table 53

CALCULATED NUMBER OF DEATHS IN ENGLAND AND WALES AND SCOTLAND IN 1937, DUE TO INFECTION WITH THE BOVINE TYPE OF TUBERCLE BACILLUS, ALL AGES

(From G S Wilson, *The Pasteurisation of Milk*, 1942)

	England			Scotland		
	Total Deaths	Bovine Deaths	Per cent Bovine	Total Deaths	Bovine Deaths	Per cent Bovine
Respiratory .	23,970	336	1·4	2,791	151	5·4
Central nervous system .	1,796	421	23·4	374	103	27·2
Intestines, peritoneum .	676	554	82	159	92	50·7
Bones and joints . . .	569	135	23	83	19	23
Lymphatic system, bronchial and glands, etc	432	92	21	57	17	30
Disseminated . . .	1,086	65	6	199	22	11
	28,529	1,603	5·6	3,663	404	11·0

Total for U K —deaths = 32,192
Bovine deaths = 2,007
Percentage bovine = 6·2

Total bovine deaths = 2,007
Total bovine respiratory deaths, i e pulmonary T B of bovine origin = 487
Pulmonary bovine T B as percentage of total bovine T B deaths = 24

This is borne out by the statement of Cutbill and Lynn (1944) who found 1·6 per cent of bovine-type infection in 2004 cases of phthisis which had not been in contact with cattle, compared with 16·4 per cent in 97 cases of phthisis which had been in contact with cattle. This emphasizes the possibility of the respiratory transfer of the bovine bacillus from cattle to man. The importance of direct inhalation infection with the

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bovine type of tubercle bacillus has not received the same attention in this country as it has in Sweden (Hedvall, 1942) and in Denmark (Sigurdsson, 1945). Sigurdsson, as a result of a very extensive study of bovine tuberculosis in rural populations in Denmark, states: "Bovine infections in man are in direct relation to the degree of tuberculosis in the cattle which the respective persons have been in contact with. The bovine pulmonary tuberculosis has to be assumed quite preponderantly to have arisen from inhalation infection—during the work of the patients in the cow stable. The rural population is in need of information about the danger of inhalation infection present in tuberculous infected cow stables. Without complete annihilation of tuberculosis among cattle this disease will never be eradicated in man."

Magnusson (1942), writing concerning the incidence of bovine tuberculosis in Sweden, emphasizes the danger children run when they play in infected cow sheds and points out that it is not enough to exclude tubercular animals from eradication areas, because persons with bovine phthisis can easily infect the herd. In Denmark not only is it authorized to remove tuberculin reacting animals from the herd but to remove also any person associated with the herd who himself or herself is found to have tuberculosis.

Several workers have emphasized the correlation between tuberculosis and the consumption of meat and milk, stressing the importance of an adequate protein intake in combatting the disease. It has been suggested in some quarters that subacute infections generally, including tuberculosis, produce nitrogen waste or depress nitrogen retention and that therefore to maintain a positive nitrogen balance the individual must have a diet which provides a larger amount of protein than that required for a normal person. An objection to much of the work on nitrogen balance in tuberculosis is that sufficient note has not been taken of the fact that rest in bed alone will cause a significant negative nitrogen balance in a normal adult even when the Calorie and protein intakes are adequate. This would seem to explain some of the statements made concerning the increased requirement of protein in cases of tuberculosis. As long as the matter is in doubt the only safeguard in the interests of the patient is to determine the nitrogen balance and act accordingly.

Attested Herds.—It may not be known generally that calves and pigs are very susceptible to infection by the bovine tubercle bacilli in milk, whey, skim milk and other products of dairy farming. Cattle are also susceptible to the organism *Brucella abortus*, which causes undulant fever, a fever not uncommon in man. In milk there are found numerous colonies of pyogenic streptococci which play a prominent part in milk-borne epidemic disease. These organisms, which cause tonsillitis, scarlet fever, epidemic sore throat, erysipelas and other septicæmic conditions are found in the udder of the cow. Many of these bovine streptococcal infections (*hæmolytic streptococci*) are of human origin.

It is clear that there is a milk problem which is bound up on the one hand with the nutritional condition of young and old but particularly of the young, and on the other with the improvement of the breeding of dairy cattle. It is true that 6 to 7 per cent of the farms in this country produce tubercle-containing milk, and 18 to 20 per cent of all cattle and about 30–35 per cent of *milch cows* react to the tuberculin test. Eradication of the tuberculin reacting cow from the herd is a matter of first importance and unfortunately in this country it has not received the attention given to it in such countries as Sweden, Denmark and the U.S A. In Denmark in 1932, bovine tuberculosis was as rife as it was in this country in the same year. To-day, as a result of the combined activity of veterinary authorities and the farming community, the disease has been eradicated. In the U.S.A. there were about 6 8 per cent of tubercular cattle in the year 1917. As the result of a drastic plan of eradication whereby all tuberculin tested reactors were slaughtered, the percentage of cattle reacting to tuberculin was, in 1942, 0 25 per cent. This was accomplished in a matter of 25 years. Of this campaign it was said that nothing could be more wasteful, extravagant and unproductive of real results; the results, however, speak for themselves and one of them is that bovine tuberculosis has practically been eradicated in the U.S.A.

Table 54 shows the number of cattle, attested herds, cattle in these herds and the percentage of attested to total cattle in England, Wales and Scotland.

Under the Tuberculosis (Attested Herds) Scheme 1950, Scotland is in the most favourable position; the Shetland Isles

were the first county to have 100 per cent attested cattle; many counties, such as Ayr, Bute, Dumfries, Renfrew, Wigtown, Kirkcudbright, have over 70 per cent attested cattle in their herds. In Wales, Cardigan and Carmarthen are the only counties which have over 70 per cent. In England, the Isles of Scilly have 100 per cent attested cattle; only one county, namely Westmorland, has over 60 per cent attested cattle. From these figures it is evident that much remains to be done

TABLE 54

TUBERCULOSIS (ATTESTED HERDS) SCHEME

Position of "Attested Herds"

From the Ministry of Agriculture and Fisheries, Animal Health Division

Country	Total Cattle as at 3rd June, 1949	Number of Attested Herds as at 30th Sept., 1950	Number of Attested Herds as at 30th Nov., 1950	Number of Cattle in Attested Herds as at 30th Sept., 1950	Percentage of Attested Cattle to Total Cattle
England . .	6,709,994	24,015	25,375	1,072,330	16.0
Wales . .	985,381	15,164	15,429	311,490	31.6
Scotland . .	1,568,570	13,303	13,518	658,450	41.9
Total Great Britain	9,263,945	52,482	54,322	2,042,270	22.0

and "there is therefore every reason for the medical and veterinary professions to collaborate in aiding the farming community and the public to eliminate tubercle bacilli from the environment of animals and man in Great Britain" (Francis, 1950). The reasons for the production of safe milk—milk free from pathogenic organisms—are numerous and are assuredly well founded. The methods by which the desired aim may be attained are: the elimination of tubercular infection from animals and from human personnel and the destruction of pathogenic organisms in milk.

METHODS FOR PASTEURISATION OF MILK

Pasteurisation of milk began on a commercial scale in the large towns of this country about the beginning of the present century. Its whole object was to destroy the common pathogenic organisms which occur in raw milk and thus render it

safe for human consumption The original method was to heat milk to about 170° F. for a very short period and to cool it rapidly: this was essentially a "flash" or short time high temperature process, but it was entirely uncontrolled with regard to time.

The Holder Method.—Most of the milk in this country is pasteurised by the "holder method", which consists in heating the milk to not less than 145° and not over 150° F, keeping it at this temperature for 30 minutes and then cooling quickly to a temperature of 50° F. The nutritional losses occasioned are about 20 per cent of vitamin C, a loss mostly due to exposure to light and not to the process *per se*, and 10 per cent of vitamin B_1. Certain enzymes are destroyed, particularly the enzyme phosphatase, the absence of which is used as a test of efficient pasteurisation. These enzyme losses are, as far as we know, without nutritional significance. Milk pasteurised by the Holder method will keep for 48 hours at 70° F. and for 72 hours at 60° F. When the milk has been bottled its keeping properties may be much reduced bottles, unless sterilised, may be responsible for rapid souring of the milk.

The High Temperature Short Time [H.T.S.T.] Method. This process, with accurate control of temperature, time and milk flow, has proved to be very satisfactory for pasteurising milk. The milk is heated to a temperature of 162° F. and held for a period of 15 seconds. With the use of thermocouples, an accurate flow control device, a continual record of temperature and a flow diversion valve for diverting any milk which has not been correctly heated, the method can be made almost entirely automatic. The film of milk as it passes over the heater is not more than 0 01 inch thick, thus ensuring that every particle of milk is heated. The milk is rapidly cooled to a temperature of 40° F. The details of the method are diagrammatically shown in Fig. 45. A typical installation, capable of handling 3000 gallons of milk per hour, is shown in Fig. 46. The temperature and time of exposure are ample to kill all tubercle bacilli in the milk treated by this method. The H.T.S.T. method was first used in this country in 1923 and was officially recognized as a statutory process in 1941. Its great advantages are economy of plant, floor space and time. It is a method of precision based on sound scientific principles. The destruction of

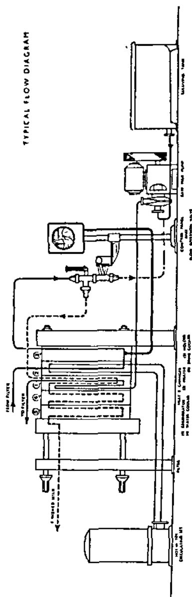


FIG. 45 —Diagrammatic representation of the milk flow in the aluminium plant and vessel short time high temperature pasteurisation plant. [*By courtesy of Aluminium Plant and Vessel Co., Ltd.*]

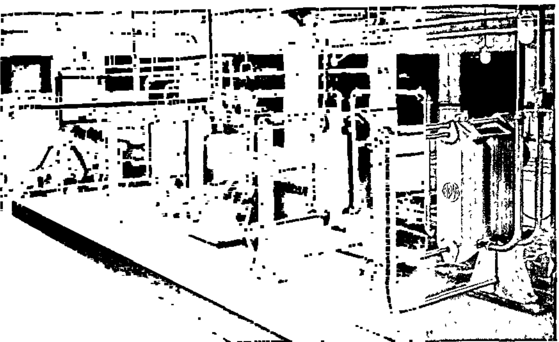


FIG. 46.—Showing A.P.V. short time high temperature pasteurising plant, Aberdeen, capacity 3000 gallons of milk per hour

[*To face page 252.*

vitamins C and B_1 is practically the same as with the Holder process. In all pasteurisation methods, the milk is rapidly cooled to prevent the multiplication of heat-resisting non-pathogenic organisms. The efficiency of these methods is tested by determining whether the enzyme, phosphatase, has been destroyed. To destroy the enzyme, the temperature must be slightly higher than that required to kill tubercle bacilli.

Sterilised Milk.—There is a growing demand for this type of milk. In its preparation it is heated to 212° F. and often higher for varying lengths of time. Sterilised milk tastes and keeps well; vitamin C and B_1 are destroyed to one-half and one-third of their original content in raw milk. The biological value of the proteins is said to be but slightly reduced.

" In Bottle " Pasteurisation.—In this method milk at 147° F. is filled into sterilised bottles, and the milk held at 145° F. for 30 minutes and then cooled. The method is ideal, but it requires extensive plant and much floor space. It would, however, guarantee the delivery of a milk safe from all pathogenic organisms.

OTHER HEAT TREATMENT PROCESSES

Dried Milk. (*a*) **The Spray or Atomiser Process.**—In this process precondensed milk is sprayed in a current of heated air in a specially designed chamber. Spray dried milk is almost completely soluble in water and is therefore easily reconstituted; the nutrient losses are as for the Holder process, namely, protein 5 per cent, vitamin B_1 10 per cent and vitamin C 20 per cent.

(*b*) **The Roller, Drum or Film Process.**—Roller dried milk, produced by heating a thin film of milk on revolving cylinders, heated internally by steam, is less soluble, and suffers slightly greater destruction of its vitamins and protein, than does spray dried milk. The milk may be dried at barometric pressure by exposure to a high temperature, or *in vacuo* at a much lower temperature. Most of the dried milk in this country is prepared by the roller process. The roller dried powders containing fat (full cream and part cream) appear to keep better than do the spray dried. National dried milk prepared in the U.K. is roller dried: there are two varieties,

full cream with 27 per cent of fat, 26·5 per cent of protein and 37·5 per cent of lactose, and half cream with 16·5 per cent of fat, 31 per cent of protein and 43 per cent of lactose. Since 1945 all national dried milk has been fortified by the addition of 280 i.u. of vitamin D per oz. of the powder, the vitamin concentrate being added direct to the milk before it is dried. No national dried milk is on sale to the general public; it is retained for infants up to two years of age and is obtained only under the Welfare Foods Scheme.

Full cream and half cream dried milk powders keep well if hermetically sealed and kept under an inert gas; they are hygroscopic and exposure to air results in oxidation processes which lead to deterioration of the powder.

Dried skim milks, where much of the fat has been removed to enhance the keeping quality of the product, are very nutritious for all except infants. With the absence of the fat, a valuable nutrient is, of course, missing, but nevertheless the milk still contains its quota of animal protein, mineral salts, riboflavin, thiamine and lactose.

Condensed Milks.—The thick, unsweetened variety is evaporated *in vacuo* at a low temperature, it is then placed in tins, sealed and sterilised at a temperature of 240° F. Vitamin C is reduced 60 per cent or more: the biological value of the proteins is definitely but not greatly reduced. If the milk be sweetened by the addition of cane sugar, it is then not exposed to such high temperatures as the unsweetened article. Cane [illegible], effectively [illegible] ° F. (boiling [illegible] preparation. The amount of nutrients remains practically the same as that of the raw fresh milk. Dried milk is concentrated to about $7\frac{1}{2}$ times, evaporated or condensed milk to about $2\frac{3}{8}$ times the strength of the original milk.

With these methods for the production of safe milk, it is somewhat strange that full accord on the subject of pasteurisation has not been reached. It is nevertheless true that for many, heat treated liquid milk is unacceptable. "In the near future it will almost certainly be a national requirement that all milk sold for liquid consumption shall either be effectively pasteurised or shall be from disease free animals." (Kay, 1942).

MILK DESIGNATIONS

Of the milk-borne diseases which call for elimination in the interests of human welfare and agricultural economy, tuberculosis and brucella infection are the most important. Upon their successful control or elimination the solution of the problems of milk production largely depend. In order to improve the quality of the nation's milk supply veterinary inspection is regulated and milk is produced under several designations: e.g., tuberculin tested (T.T.), accredited, pasteurised, sterilised. These designations differ somewhat for England and Wales, and for Scotland. They are as follows:

England and Wales.—The Milk (Special Designation) (Pasteurised and sterilised) Regulations, 1949. No. 1589.

These regulations came into operation on 1st October 1949, as a result of the combined action of the Minister of Health and the Minister of Food. They re-enact, with amendments, the Milk (Special Designations) Regulations 1936–48 in so far as they relate to pasteurised milk and provide for a new special designation "Sterilised Milk". They are therefore concerned only with special designations of heat treated milk, the descriptions being "Pasteurised" and "Sterilised".

Pasteurised Milk. The following conditions apply to milk in relation to which the special designation "Pasteurised" is used:

The milk shall be pasteurised, that is to say

(a) retained at a temperature of not less than 145° F. and not more than 150° F. for at least 30 minutes and be immediately cooled to a temperature of not more than 50° F.; or

(b) retained at a temperature of not less than 161° F for at least 15 seconds and be immediately cooled to a temperature of not more than 50° F , or

(c) retained at such a temperature for such a period as may be specified by the licensing authority with the approval of the Minister

The reg[illegible]

atmospheric contamination by dust or otherwise; that the

method by which the temperature of the milk or the medium by which the milk is to be maintained at any temperature shall be automatically controlled; that where the milk is heated to a temperature over 150° F. a device shall be installed which will automatically divert the flow of any milk which is not raised to the authorized temperature. The milk so pasteurised must before delivery to the consumer satisfy the Phosphatase Test, as also the Methylene Blue Test, both of which are fully described in the regulations. From 1st October 1950 until 1st October 1951, the regulations demand that milk which is pasteurised in bottles shall be delivered to the consumer in those bottles, and milk which is pasteurised in containers other than bottles shall be put into the containers in which it is to be delivered to the consumer only by a person holding a licence under the regulations to use the special designation "Pasteurised" and on the premises named in that person's licence. Containers in which the milk is transported, exposed or offered for sale shall be conspicuously and legibly marked with the words "Pasteurised Milk".

Sterilised Milk. The regulations which apply to milk for which the special designation "Sterilised" is used require that the milk be filtered or clarified, homogenised and heated to and maintained at such a temperature, not less than 212° F., for such a period as to ensure that it will comply with the Turbidity Test which is prescribed in the schedule; and be treated in bottles in such a manner that on completion of the treatment the bottles shall be sealed with an airtight seal. It is also required that thermometers and pressure gauges be installed in suitable places in the apparatus; and that a sample of the milk taken after treatment and before delivery to the consumer shall satisfy the turbidity test. Every bottle in which the milk is transported, exposed or offered for sale must be conspicuously and legibly marked with the words "Sterilised Milk" or "Tuberculin Tested Milk (Sterilised)" as the case may be.

The Milk (Special Designation) (Raw Milk) Regulations, 1949. No. 1590. These regulations re-enact with amendments the Milk (Special Designations) Regulations 1936–45 in so far as they relate to raw milk. The special designations authorized by these regulations which may be used in relation to milk are "Tuberculin Tested" and "Accredited". Subject to the restrictions on the use of the special designation "Accredited",

imposed by the Milk (Special Designations) Act 1949, a licence authorizing a person to use the special designation "Tuberculin Tested" shall entitle him to use the special designation "Accredited" in relation to the milk to which that licence applies. This permission is valid only for a period of 5 years from the commencement of these regulations or for such shorter period as the licence may be in force

All producers' licences granted on or after the commencement of these regulations to use the special designation "Tuberculin Tested" in relation to milk produced from attested herds are valid only for a period of 5 years from the date on which the licence was granted. If an application for a licence is received after 30th September 1951 and before 1st October 1954, to use the special designation "Tuberculin Tested" in relation to milk produced from herds not being attested herds, the licence shall be granted only for a period of 3 years and is thereafter not renewable. After 30th September 1954, no licence will be granted to an application unless the herd in respect of which the licence is applied for is an attested herd With regard to the designation "accredited", applications received before 1st October 1952 in relation to milk produced from any herd shall be granted for such part as there then remains of the period of 5 years from the commencement of these regulations and shall not then be renewable After 30th September 1952, no licence to use the special designation "Accredited" shall be granted.

Scotland.—The Milk (Special Designations) (Scotland) Order, 1951 No. 644 (S.31).

These designations have their origin in the Milk (Special Designations) Act, 1949. Certain changes have been made; the designations "Certified", "Tuberculin Tested" and "Pasteurised" are recognized as before and the designation "Tuberculin Tested (Pasteurised)" may continue to be used. No new "Heat Treated" licences will be granted and all licences to use this special designation will end on 31st December 1951. After 30th September 1952, no applications will be received for licences to use the special designation "Standard" and after 30th September 1954, this designation will be discontinued. A new designation "Sterilised" has been introduced in this Order.

No licence will be granted to use the special designations "Certified" and "Tuberculin Tested" after 30th September 1934, unless the milk to which it refers has been produced from an attested herd. At present if the herd is not an attested one certain conditions have to be fulfilled, namely: every animal in the herd must be submitted to a tuberculin test by a veterinary inspector; no animal may be added to the herd unless it has passed a tuberculin test within 14 days before it is so added; every animal in the herd must be suitably marked for the purpose of identification and must be registered; every animal in the herd must be submitted to examination by a veterinary inspector at such times as may be required by the Minister of Agriculture and Fisheries. It is also required that where an animal belonging to an attested herd shows evidence of any disease likely to affect the milk injuriously it must be segregated or removed from the herd.

Certified Milk. It is required that all milk in this category be cooled immediately upon production to a temperature not exceeding 50° F. and immediately after cooling placed in retail containers on the premises where it was produced. Every such container must bear in some prominent position the name of the premises where the milk was produced and the words "Certified Milk". The milk must not at any stage be treated by heat or in any manner likely to affect its nature or qualities and any sample of the milk taken after cooling and before delivery to the consumer must not contain more than 30,000 bacteria per millilitre nor coliform bacteria in one tenth of a millilitre.

Tuberculin Tested Milk. After production all such milk must be cooled on the premises to a temperature not exceeding 50° F. It must be placed in retail containers marked with the words "Tuberculin Tested Milk" or in unventilated bulk containers similarly labelled. The milk must not be treated by heat nor in any manner likely to affect its nature or qualities. Any sample of the milk taken after cooling but before delivery to the consumer must not contain more than 200,000 bacteria per millilitre nor coliform bacteria in one hundredth of a millilitre.

Standard Milk. Every milk cow in a herd producing "Standard Milk" must be suitably marked for the purpose of identification, must be submitted to an examination by a veterinary inspector and a register of such cows must be kept. As in the previous cases, an animal belonging to such a herd and

showing evidence of disease likely to affect the milk injuriously must be segregated or removed from the herd It is further required that immediately upon production the milk be cooled to a temperature not exceeding 60° F., be placed in retail containers bearing the words "Standard Milk" and the name of the producer, or in unventilated bulk containers similarly labelled. The milk must not be treated by heat nor in any manner likely to affect its nature or qualities. Any sample of the milk taken after cooling but before delivery to the consumer must not contain more than 200,000 bacteria per millilitre nor coliform bacteria in one hundredth of a millilitre

Pasteurised, Heat Treated and Sterilised Milk.

Pasteurised Milk. Special conditions apply to those holding licences authorizing the use of the special designation "Pasteurised". Briefly, they are that the milk must be pasteurised by (*a*) being heated for a period of 30 minutes at a temperature not less than 145° F. and not more than 150° F and immediately cooled upon termination of the period of heating to a temperature not more than 50° F., or (*b*) being heated to and maintained for a period of at least 15 seconds at a temperature not less than 161° F. and not more than 178° F. and immediately after the termination of the said period cooled to a temperature not more than 50° F. It is further required that the apparatus in which the milk is pasteurised be satisfactory to the local authority; this means that the apparatus must be provided with a device which will automatically prevent any milk not raised to 161° F. from flowing into the cooler. Recording thermometers must be installed in suitable places and every record made by a recording thermometer must be marked with the date on which it is made and preserved for a period of not less than 3 months The milk so produced must, immediately after cooling upon the premises in which it was pasteurised, be put into retail containers bearing the words "Pasteurised Milk" and the name of the holder of the licence If the container be a bottle the name of the licence-holder and the words "Pasteurised Milk" should be borne on the cap If the milk be put into unventilated bulk containers it must be similarly labelled. Any sample of the milk taken after pasteurisation but before delivery to the consumer upon being tested must (*a*) on submission to a phosphatase test

give a reading not exceeding 2·3 Lovibond blue units and (*b*) be found to contain no coliform bacteria in one hundredth of a millilitre.

Heat Treated Milk. The milk must be treated by heat in apparatus of such a type and by such methods as are satisfactory to the local authority. The milk must not at any time be or have been raised to a temperature of more than 178° F. and immediately after heat treatment it must be cooled to a temperature not exceeding 60° F. After cooling the milk must be placed in retail containers bearing the name of the premises where it was produced and the words "Heat Treated Milk", or in unventilated bulk containers similarly marked. Any sample of the milk taken after heat treatment but before delivery to the consumer must, on submission to a phosphatase test, give a reading not exceeding 2·3 Lovibond blue units.

Sterilised Milk. After being filtered or clarified, and homogenised, the milk must be sterilised by being heated in capped bottles to and maintained for 30 minutes at a temperature not less than 220° F. and not more than 235° F., so that on completion of the treatment the bottles are hermetically sealed. The bottles must bear the name of the premises where the milk was sterilised and the words "Sterilised Milk". It is required that thermometers and pressure gauges be inserted in suitable places in the apparatus to indicate the temperature to which the milk was raised and the pressure to which it has been subjected. The bottles must remain hermetically sealed until delivery to the consumer. Any sample of the milk must satisfy the turbidity test.

The Order contains full particulars concerning the necessary tests—the bacterial count, the phosphatase and turbidity tests.

THE EXAMINATION OF DAIRY HERDS

Where before 1st October 1954, application is made for a producer's licence to use the special designation "Tuberculin Tested" and the herd in respect of which the licence is applied for is *not an attested herd,* it is necessary to furnish the Minister of Agriculture and Fisheries with:

(*a*) a certificate of a tuberculin test of every animal in the herd at the date of the application, the test to be carried out not more than one month before the date of application and distinguishing every animal by its identification mark;

(*b*) a veterinary surgeon's certificate of an examination of every animal in the herd at the date of the application carried out not more than one month before that date.

It is also necessary to satisfy the Minister that any animal reacting to the tuberculin test has been removed from the herd and that any animal showing evidence of any disease which is likely to affect the milk injuriously has been segregated from the rest of the herd or removed from it.

It is also required by the regulations that if a person applies for a licence before 1st October 1952, to use the special designation " Accredited " he shall

(*a*) furnish the Minister of Agriculture and Fisheries with a veterinary surgeon's certificate of examination of the milch cows in the herd carried out not more than one month before the date of application ;

(*b*) satisfy the Minister that any such cow which has been certified as showing evidence of any disease likely to affect the milk injuriously has been segregated from the rest of the herd or removed from it, as the case may require.

The Tuberculin Tested Herd.—Special conditions have been set forth upon which licences can be obtained authorizing the use of the special designation " Tuberculin Tested ". They are :

1. If the herd at the time the licence is granted is attested

attested herd, every animal in the herd must be submitted to a tuberculin test by a veterinary inspector at such times as may be required by the Minister of Agriculture and Fisheries. No animal may be added to the herd unless it has passed a tuberculin test within 14 days before its addition to the herd ; or, in the case of an animal taken directly from an attested herd or a herd in respect of which a licence, authorizing the use of the special designation " Tuberculin Tested " is in operation on the occasion of the last test in that herd. Within 7 days after the addition of an animal other than an animal taken from such a herd, the certificate of a tuberculin test shall be sent to the Minister with a notification of the date of the addition. The

animal must be segregated from the rest of the herd until it has been submitted to a tuberculin test by a veterinary inspector not earlier than 60 days after the date of its addition. All tuberculin tested cows must be suitably marked for the purposes of identification, a complete register of them must be kept; they are submitted to veterinary examination at times prescribed by the Minister of Agriculture and Fisheries and the herd must be completely isolated from all other cattle. The milk in relation to which the designation "Tuberculin Tested Milk" is used must not have been heat treated, must be bottled or placed in unventilated bulk containers by the producer and sold in such bottles or containers. After 1st October 1957, the special designation "Tuberculin Tested" may only be used in respect of milk from a tuberculin tested herd which is on the Register of Attested Herds kept by the Minister of Agriculture and Fisheries.

The Accredited Herd.—Special conditions have also been laid down in the regulations authorizing the use of the special designation "Accredited" in respect of herds. The main conditions are .

Every milch cow belonging to the herd must be submitted to an examination by a veterinary inspector at such times as may be required by the Minister of Agriculture and Fisheries. Where an animal shows evidence of any disease likely to affect the milk injuriously it must be segregated from the rest of the herd or removed from it. The cows and milk belonging to such a herd must be kept separate from all other cows and milk, and the milk for which the special designation is used must be placed in bottles by the producer under certain conditions named in the schedule or placed in unventilated bulk containers suitably labelled with the words "Accredited Milk". After the 1st October 1954 the special designation "Accredited" will not be permitted and no application to use the designation will be granted after 30th September 1952.

All raw milk must satisfy the Methylene Blue Reduction Test, that is to say, it must fail to decolorize the methylene blue in 4½ hours between 1st May and 31st October and in 5½ hours between 1st November and 30th April. This test is fully described in the regulations.

Despite a high mortality, chronic invalidism and crippling arising from bovine tuberculosis, large numbers of the people

in England, Scotland and Wales are still exposed to all the dangers of raw milk. The eradication of tuberculosis from United Kingdom herds is the very basis of the problem. But the production of safe milk from safe cows will necessitate vast changes in the administration of many farms throughout the land. Farmers must be encouraged to equip their farms with modern appliances, to install adequate water and electric power, and generally helped to train their farm personnel in the techniques of animal hygiene. When this is done, veterinary and medical officers will be in a stronger position than they have been in the past to criticize, advise and, when necessary, to take action. It must never be assumed that cleanliness means safety in the production of milk. It is certainly a long step towards the desired aim, but until all tuberculin tested milch cows remain negative to the test, are free from the organisms of undulant fever and all milk is bottled immediately upon delivery, by sterilised apparatus from the udder, then pasteurisation must not be discarded. In arriving at a fair judgment on the pasteurisation of milk, one must be careful not to argue from the particular to the general. Undoubtedly many parts of the country, particularly rural areas, see little of milk-borne epidemics, and are supplied with raw milk of a high standard of cleanliness, but many are not so favoured. The problems of the rapid transportation of milk to and its delivery in large cities will remain problems until the "milk-refrigerator car" has become a reality Clean milk is still not safe milk; the bacilli of tubercle, dysentery, epidemic sore throat, etc, can still be carried by clean milk, as the figures published by the [illegible]

from T.T herds and had not also been pasteurised. Pasteurisation is necessary, not that, because of it, the dangers of milk may be ignored, but that, knowing the dangerous possibilities of milk, the community may be safeguarded while the problems of its safe production are being solved.

The Cream Line in Pasteurised Milk.—The most frequent criticism levelled against pasteurised milk, particularly the H.T.S T. process, is that, because of the reduction of the cream line, some of the cream has been removed The apparent loss of cream is due to the change in the physical aggregation

of the fat globules produced by heating and is not indicative of any diminution in the amount of fat or alteration in its nutritive value.

Lactic Acid Organisms in Milk.—It is well known that heated milk does not sour so readily as fresh milk. Souring is due to the presence of lactic acid bacteria found in fresh milk by contamination after the milk has been obtained from the cow. If the lactic acid bacteria be allowed to proliferate, the milk may become sufficiently acid to bring about the destruction of pathogenic organisms in the milk. The milk will also become sour due to the formation of lactic acid from lactose by bacterial action. Pasteurised milk in which the lactic acid bacteria have been largely destroyed does not readily sour on standing, but like fresh milk, if left uncovered and uncooled, will become unpleasant. This is due to changes in the nature of the protein of the milk. When milk curdles, it indicates that the amount of acid formed has been sufficient to precipitate the milk protein—caseinogen.

Upon the addition of rennin (chymase) to milk, it clots or coagulates; the nature of this change is doubtful but it is probable that an insoluble calcium salt of casein is formed. When this action takes place, a jelly or junket is formed, the clot shrinks, becomes entangled with the fat of the milk, thereby forming the curd or curds and subsequently expresses a yellowish fluid which is called whey. The distinction between the acid curdling and the enzymatic clotting will be noted.

Pasteurised milk, unless kept for several hours, clots with rennin just as readily as the fresh article: if it did not, it could not be used in the making of cheese. Milk which has been boiled will not clot with rennin. Milk pasteurised by licensed methods will behave as fresh milk, provided there is no greater delay in using it than there normally is with fresh liquid milk.

THE CLEANING AND STERILISATION OF DAIRY EQUIPMENT

Stainless Steel Pasteurising Plant.—The main points for consideration are the presence of bacteria and milkstone. The best form of sterilisation naturally is water at boiling point and the Milk and Dairies Regulations of 1949 require that "all milk utensils should be thoroughly washed with or without

detergents and before being used again should be scalded with boiling water or steam or otherwise effectively cleansed with an oxidizing or preservative agent approved by the Ministry of *Agriculture and Fisheries and the Ministry* of Food " Before 1943 oxidizing agents were permitted only for the treatment of milking machines, but in that year the use of approved substances for the effective sterilisation of all utensils was permitted but was not to be regarded as an alternative to boiling water or steam. The chief difficulty with the plate type heat exchanger used for milk pasteurising in the H T.S.T. machines is the formation of milkstone; when milk residues have hardened on the surface or in the corners of stainless steel machinery, acids must generally be used from time to time for their removal. Investigations have been carried out designed primarily to eliminate the necessity for acids and to reduce the brushing of plate to a minimum. A method, described by Botham at the 12th International Dairy Congress at Stockholm in 1949, depends upon the action of higher sodium phosphates on the proteins of milk scale and is applicable to softened or hard water; in this method of cleaning and sterilising apparatus, the circulating water is maintained at 75° C, the detergent "Calgon" is added to the circulating water and the water allowed to circulate for 20 minutes. Without stopping the circulation sufficient alkali-NaOH- to give a 0 5 per cent weight/volume strength in the machine is added; caustic soda alone or in commercial alkaline detergent may be used, and the circulation continued for a further period of 20 minutes, after which the solution is drained off, the apparatus flushed with water at 75° C. and finally with cold water. The advantage of this method in preventing milkstone formation is that no acid is required; by the addition of suitable wetting agents to higher phosphate solutions, alkali need not be used if the milk runs are short.

Milk Utensils.—For cleansing and sterilising milk utensils it has been found that solutions of sodium hypochlorite will destroy the majority of bacteria on the surface of utensils provided they have been thoroughly washed and are in a good state of repair. Solutions of sodium hypochlorite approved by the Ministries of Agriculture and Food are on the market under

certain trade names—Deosan, Chloros, Dairozon, Hyposan, Delsanex. These preparations must upon despatch from the manufacturers' premises contain between 9 and 12 per cent of available chlorine, not less than 0·7 per cent of sodium chlorate and not more than 2 per cent of free caustic alkali. As the strength of hypochlorite solutions falls off progressively, it is necessary to discard solutions which have been kept too long and occasionally to treat all utensils with boiling water or steam.

In practice dairy utensils can be cleaned most effectively by using a hypochlorite solution as a hot wash in combination with a detergent, a treatment which is referred to generally as a "chlorine wash". The detergent assists the wetting and removal of milk residues, thereby facilitating the penetration of the chlorine to all surfaces; it also minimizes to some extent the danger of corrosion. Hypochlorite solutions are made up in strengths appropriate to the use to which they are to be put; the strength of the chlorine solution being expressed as parts of available chlorine per million parts of water. Any mild detergent (soda ash or washing soda) may be used; a chlorine wash may be prepared by dissolving ½ lb. washing soda in 10 gallons of water at 112° C. and adding the stock hypochlorite solution. All utensils are finally rinsed with a "chlorine rinse" or water and inverted on a suitable rack to dry.

The Cleaning and Sterilisation of Milk Bottles.—The problem of the bacteriologically clean milk bottle is a very real one. Suggestions to replace bottles by cartons have been made; this, however, will not easily be accomplished because much capital in the dairying industry is sunk in bottling plants. Given a carton which could be sterilised, closed with a cap, and which would not be too readily affected by external condensation on the outer surface of the carton containing cold milk, there should be little difficulty in modifying the present bottling methods so that by piercing the cap of the carton it may be filled with pasteurised milk and the appecture immediately closed. The carton should then be placed in a refrigerator, delivered cold and discarded when empty. The danger of using imperfectly sterilised bottles would thus be avoided, and not only would the noise occasioned by the use of bottles become a fading memory, but the disadvantages of their fragility would disappear.

Much careful work has been undertaken in order to determine how best to clean and sterilise milk bottles Hand washing, steam sterilisation, cleansing by detergents, have all been examined. The first has been condemned, the second proved not to be very satisfactory, the last, followed by rinsing with hot water and external cooling of the bottle, has been found the most satisfactory. Several machines of new design are in use in which the strength of the detergent is well controlled, the final washing of the bottle effective in removing the detergent and the external cooling adequate. They are based on comparatively recent surveys of bottle washing plants undertaken to determine the most effective method for cleaning and sterilising milk bottles. In this country the most important of these surveys was carried out by Hobbs and Wilson, a summary of whose report to the Ministry of Health is to be found in the *Journal of Hygiene* (1943) They have made it quite clear that the two main factors concerned in the destruction of bacteria are the concentration and the temperature of the caustic detergent used in cleaning the bottles. The required result can be attained by using either a weak caustic solution (1·46 %) at a high temperature (160° F.) or a strong solution (2·44 %) at a lower temperature (120° F.), the time of exposure being 1 minute. If the time of exposure be 4 minutes the strength of the solutions can be halved. The detergent solution used in bottle washing machines contains, in addition to the caustic soda, sodium metasilicate, sodium hexametaphosphate, trisodium phosphate and sodium carbonate made up in such a way as to give a proper balance between the various qualities of fat saponification and dispersive power. Bottles emerging from the detergent section in properly operated plants are virtually sterile. The subsequent rinsing processes expose them to bacteriological recontamination. Contamination may be avoided by the addition of chlorine to the rinse water, a procedure not advocated by Hobbs and Wilson since it " is likely to degenerate into an excuse for dirtiness ". These authors recommend that to remove the detergent the bottles should be internally sprayed in the inverted position with *hot* water at a temperature high enough to inhibit bacterial growth, cooled by *external* rinses of water progressively decreasing in temperature and finally cooled by a rinse with cold mains water both internally and externally. The bottles should then be allowed

time to drain effectively, a wide neck pint bottle for example, should drain for 1 minute. The bottles at a temperature of not more than 68° F. should be immediately filled with milk and closed with a press-in disc cap and a hooded cap. The ordinary custom of using a press-in disc cap without any further covering is to be condemned, for it leaves the top of the bottle open to contamination from both human and animal sources. Modern bottle washing machines with close attention to strength and temperature of detergents, cleaned daily with 1 per cent caustic soda, thoroughly washed with cold mains water and having all jets, manifolds and distributor bands scrupulously cleaned after each run, will produce bottles of a high degree of cleanliness.

It has been suggested that milk be pasteurised in the bottle. This is a sound suggestion. It has also been suggested that if milk were hygienically delivered direct from the tuberculin tested cow by sterilised apparatus to a sterilised bottle or carton, it would not require to be pasteurised. Provided milk bottles are cleaned by the modern methods referred to the milk would be tolerably safe and clean and would have good keeping properties, but, in contrast to the "in the bottle" pasteurised milk, it could not be guaranteed free from pathogenic organisms.

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CHAPTER XIV

PROTEIN RICH FOODS

MILK : CHEESE : EGGS : MEAT : FISH

YEAST : FOOD SPOILAGE AND FOOD POISONING

PROTEIN, the essential fabric of living tissue, is the material basis of all vital activity; upon its variety of structure a diversity of function depends—growth, repair and reproduction, osmotic relationships, immunity and endocrine reactions. A brief consideration of the chief protein rich foods, prime source of the *indispensable amino-acids, seems essential* in view of the important part they play in nutrition.

Milk.—Milk, the best and most economical of the animal protein foods, has been considered in the previous chapter; it will be referred to only by way of comparison with the other foods mentioned here.

Cheese.—Cheese making, one of the primitive arts of husbandry, was probably introduced into this country by the Romans. In mediæval times the making of cheese was one of the chief duties of the farmer's wife, both whole and skim milk being used. In the seventeenth and eighteenth centuries many English counties, Somerset, Shropshire, Kent, Cheshire, to mention but a few, were known for their cheeses. Stilton cheese is known as such from the fact that it was supplied to the Bell Inn at Stilton in Huntingdonshire on the Great North Road, by those who made it at Melton in Leicestershire.

Composition of Cheese.—*Cheese is a very* concentrated protein food, and the methods of making it vary considerably. The method is fundamentally based upon the following processes: the milk, generally pasteurised, is heated in vats to the required temperature; a "starter", consisting of milk in which lactic acid bacteria of fairly pure strain has been cultivated, and rennin, a proteolytic enzyme, are added; the milk is then left to form a curd or junket. The manner in which the casein existing in the milk as a colloidal dispersion of a calcium salt forms a gel or clot is not clearly understood but the casein gel with the entangled fat is the basis of practically all cheese.

When the curd is of required consistency it is removed from the whey, subjected to pressure and moulded into shape. The cheese is then rolled in calico, stored under conditions of controlled temperature and humidity, and left to mature. The temperature and the degree of acidity of the curd play an important part in determining the quality of the finished product. Table 55 shows the percentage composition of various well-known cheeses. the difference in protein and fat content of the hard in contrast to the soft or cream cheeses should be noted. Containing not only the protein and fat but most of the calcium and phosphorus and the fat soluble vitamins of the milk

TABLE 55

THE COMPOSITION OF CHEESE

(McCance and Widdowson, *M R C Sp. Rep Series*, No 235)

Cheese	Protein g /100 g	Fat g /100 g	Calories per 100 g.	Calcium mg /100 g	Iron mg /100 g	Phosphorus mg / 100 g
Cheddar	24 9	34 5	423	810	0 57	545
Cream	3 2	86 0	813	29	0 14	44
Dutch	28 1	16 8	271	900	0 78	478
Gorgonzola	24 8	31 1	392	540	0 50	375
Gruyère	36 8	33 4	461	1080	0 26	698
Parmesan	34 4	29 7	417	1220	0 37	772
St Ivel	23 1	30 5	379	483	0 72	375
Stilton	25 1	40 0	475	362	0 46	304

from which it is prepared, cheese is a most valuable food The fat content of cheese depends upon whether it is made from whole milk, skim milk or milk to which cream has been added (*cp* Stilton to which extra cream is added) The English-made cheeses, Stilton, Cheddar, Cheshire, St. Ivel and others have all gained a high reputation. In view of the quality of the English cheese, it is perhaps unfortunate that home production forms such a small proportion of the total amount consumed in this country. *In 1938 the total consumption of cheese* per head per week in the United Kingdom was 2 7 oz, and of this only 0 6 oz. was home produced. The great and increasing demand for fresh liquid milk will tend to restrict the home production of cheese for some considerable time. It is hoped, however, that the variety of cheeses previously obtaining, due

to imports from New Zealand, Canada, Holland, France and Italy, will return in even greater strength in the future. Cheese, containing in concentrated form most of the nutritive elements of milk and having excellent keeping qualities, should hold a far more important place in the diet of the people than it does at present.

In 1935 the League of Nations standard for cheese consumption was given as 6·5 oz. per head per week. The Stiebling standard (U.S.A.) is 5·5 oz., which is at least three times the average American consumption rate. The consumption in this country in 1938 was 2·7 oz. per head per week. To-day, after eleven years of a minimal and monotonous diet, the people of the United Kingdom still find, apart from those who require special rations, that a ration of 3 oz. of cheese per head per week is ample. The high figures mentioned for cheese consumption have only been approached in Switzerland, Holland and France. The reason for the low consumption of cheese in Great Britain is doubtless due to the pronounced flavour of cheese. The fact that cheese contains a high percentage of fat which is intimately associated with the protein of the cheese accounts for its slow digestion; in the stomach the digestive activities of pepsin in an acid medium are delayed in virtue of the fat, but in the small intestine, where the cheese is acted upon by trypsin in an alkaline or neutral medium, digestion is practically complete. Protein digestion in this case cannot be completed until the fat of the cheese has been dealt with by the fat-splitting ferment in the pancreatic juice in the upper part of the small intestine. Far from being indigestible, cheese is most readily dealt with by the ferments in the alimentary tract and, being almost completely absorbed, is in every way an excellent foodstuff. Previous to the war modern dietaries had led to the development of an appreciation of delicate flavours, such as are obtained in fruits, meats, eggs and cheese. It is to be hoped that with more scientific knowledge of what constitutes and produces a specific flavour or taste, it will be possible to market cheeses, the taste and flavour of which would be their own recommendation.

Tuberculosis and Cheese.—To-day all cheese is manufactured by commercial firms; pasteurised milk is used; the risk, therefore, of infection by tubercle bacilli in cheese may be regarded as non-existent.

Eggs.—Eggs are very rich sources of certain body-building materials—protein, vitamins A and D and calcium, phosphorus and iron. A hen's egg consists of 10 3 per cent shell, 57 6 per cent white, 32·1 per cent yolk. The edible portion contains 12 6 per cent protein, 11·3 per cent fat and 0 8 per cent carbohydrate. The white of the egg is essentially a solution of proteins (ovalbumin) and mineral salts. The yolk contains 16 6 per cent of proteins of which there are two, vitellin, a phosphoprotein resembling caseinogen of milk, and a globulin, livetin The yolk is very rich in fat—31 7 per cent—vitamins A and B_1 and contains appreciable amounts of riboflavin, vitamin D and nicotinic acid but does not contain vitamin C. A comparison of the nutrient values of 1 pint of milk, 1 oz. of cheese and 1 egg is given in Table 56; it shows how excellent nutritionally these foods are

The egg, which is produced at a temperature of 108° F, cools after laying with the result that air is drawn into the egg through the pores of the shell; thus is formed the egg sac at the broad end of the egg. The egg is made up of two parts, the yolk and the white; in the former is the embryo which is kept alive by the interchange of oxygen and other gases between it and the atmosphere through the fine pores of the shell. These pores are the means whereby micro-organisms gain access to the egg. It is therefore necessary, to maintain the quality of the egg, that its surface should be clean and not too porous. To preserve the egg from micro-organisms—bacteria, moulds, yeasts—there are within the white of the egg natural defence mechanisms which are enhanced by keeping the egg in a cool, dry place. This is the only means whereby deterioration of the egg by ageing can be slowed down; the egg at 80° F. will in one week suffer as much damage in this respect as the egg kept for three weeks at 60° F. It is therefore desirable that eggs should be stored at temperatures below 50° F.

Previous to the war egg consumption in the United Kingdom was 3 4 eggs per head per week; of this number 1 8 were home produced. Of imported eggs practically 90 per cent came from non-Empire countries—Denmark, Holland, Belgium and Poland To-day shell eggs are produced in Great Britain, imported from Denmark, Holland, Eire, Australia, Poland and Canada; dried eggs are also imported from the U.S.A, Canada and Australia. The reorganization of poultry farming should

in time restore European sources of supply lost to us during the war. New advances in the methods for the dehydration of foods, supervised by the Food Investigation Board of the Department of Scientific and Industrial Research, should open up a wider market in this country for eggs from China. In the year 1937–38 Great Britain imported from China in liquid form, the equivalent of 1000 million eggs in shell. The possibility of

TABLE 56

THE COMPOSITION OF THE HEN'S EGG

per 100 grams

Compiled from *Nutritive Values of War-time Foods*, H.M.S.O., 1945 and *The Testing of Eggs for Quality*, H.M.S.O., 1949

Nutrient	Protein g	Fat g	Carbohydrate g	Vit. A I.U.	Vit. B₁ mg	Calcium mg	Phosphorus mg	Iron mg	Calories
Egg, whole[1]	11 3	10 1	0 8	880	0 13	60	180	3 0	140
" yolk	10 0	31 7	—	3000	0 15	131	495	6 13	350
" white	10 4	0 1	—	—	—	5	83	0 10	37
" dried	45 8	42 0	3 2	3000	0 40	210	—	11 5	574
A COMPARISON OF MILK, EGGS AND CHEESE									
One pint of fresh milk contains	19 0	21 0	26 0	800	0 23	680	541	0 35	360
One egg, weight 60 g, contains	6 7	6 0	0 4	528	0 07	36	108	1 8	84
Cheese, 1 oz. (Cheddar) contains	7 1	9 8	—	370	0 10	231	156	0 2	131

[1] By weight including the shell

transporting eggs in the dry form will give a tremendous impetus to this section of the trade in eggs. The war-time scarcity of eggs has impressed upon most the part which they should play in all dietaries. It is not too much to state that a consumption rate of 1 egg per day per head of the population should be accepted as our standard.

Meat.—The term meat includes the flesh of mammals, poultry and fish, for these are almost identical as far as nutrition is concerned. The important point with regard to meat is that

it contains proteins of high biological value. Approximately, lean meat is made up of protein 20 per cent; water 75 per cent; with a varying amount of fat within its texture. There are practically no carbohydrates in meat; but protein will give rise to sugar, 58 per cent of its carbon being converted into glucose in the body. Beef, veal, lamb and pork contain from 18 to 22 per cent of protein, while the fresh organs, liver, kidney, tongue and sweetbreads have 17 to 19 per cent. The nutritive value of meat is enhanced by the presence of fat, not that which is seen in layers on top of the meat or under the skin of the animal, but that within the tissue. It is the fat which improves the flavour but slows digestion. Mineral salts and extractives add to the appetizing taste and to the flavour of meat. Extractives are readily soluble in water and upon them depends the tastefulness of the soups made from meat. They stimulate appetite and digestion and therefore to begin a meal with soup is a very sound physiological procedure. Extractives of meat are of importance because they are of two kinds; those which give rise to uric acid in the body and those which do not. Uric acid is not entirely a waste product, a certain amount is excreted by the kidneys, but some is reabsorbed by them in order to keep the uric acid content of the blood at its physiological level. When there is an excess of uric acid in the blood stream, there may be some delay in reducing it to the normal level and in some cases it may never be so reduced. Uric acid is the end-product of the breakdown of the nucleo-proteins, which are complex combinations of proteins with nucleic acid and are found in the body as well as in the meat ingested. It should be noted that red muscle does not necessarily contain more uric acid-forming substances than white. Meats are acid forming, not because of the presence in them of uric acid or uric acid-forming substances, but because they contain comparatively large amounts of the minerals, phosphorus and sulphur. In meat, the balance between acid-forming and base-forming elements is in favour of the acid, and where there is a preponderance of phosphorus and sulphur over sodium, potassium and calcium, then the blood becomes less alkaline and the urine more acid than normal, a change which favours the deposition of salts in various tissues.

Meat is a good source of iron, but in this respect it is by no means so valuable as liver, kidney and egg-yolk. And also

with regard to its proteins of high biological value, these are no more valuable than those of milk and eggs. Meat is deficient in calcium and vitamin C; the calcium, but not the vitamin C, deficiency can best be made good by milk. The extent to which milk can replace beef as a source of certain important nutrients is shown by comparing the nutrient content of 1 pint of milk, which contains 19 g. of protein, with beef (4·0 oz., = 115 g) containing the same amount of protein:

Nutrient	Cals	Protein g	Fat g	Calcium mg	Phosphorus mg	Iron mg.	Vit. B_1 mg	Riboflavin mg	Nicotinic acid mg
Whole milk) (1 pint)	360	19	21	680	541	0 35	0 23	0 98	0 62
Beef (stewing) (115 g) .	323	19	18	12	202	4 4	0 12	0 12	5 0

Only with respect to iron and nicotinic acid is milk inferior to beef. Meat and milk proteins are excellent sources of all essential amino-acids and the milk fats are equally important as sources of essential fatty acids. Another point of interest here is that meat has been shown to be rather a rich source of anti-anæmia vitamins—folic acid and vitamin B_{12}.

The organs, liver, heart, kidneys, thymus, pancreas, are richer in iron than is muscle, but they are also richer in acid-forming substances. Beef, poultry and fish are good sources of phosphorus, fish and poultry being superior to beef. Of fish, herring, salmon and mackerel are the best, in the order named. Chicken has a phosphorus content comparable to that of mackerel. The whole egg comes in the same category, but egg-yolk is greatly superior to all of them in its phosphorus content.

The Advantages and Disadvantages of Meat in the Diet.—The advantages are that good meat is easily cooked, it stimulates appetite, is well digested and is a fuel substance which contains complete proteins. Its disadvantages are: it contains more uric acid-forming substances than most foods, a disadvantage which it shares with eggs, it is poor in calcium and vitamins and is generally more expensive than most of the rich protein foods. Of the flesh foods, fish is generally, in

coastal areas the cheapest; while it has less iron and extractives than meat, and is therefore to some never so tasty as meat, it has a high content of phosphorus, and certain fish, such as herring, are rich in vitamins A and D.

While meat certainly has appetizing properties which make it an attractive and valuable addition to one's dietary, it contains nothing which would make it an indispensable foodstuff. The gloomy picture often drawn of those who suffer from arthritis, chronic rheumatism, kidney pains, intestinal toxins, and headaches and fatigue as a result of eating uric acid-producing meat is one with which we are all familiar. It is, however, not a reflection on meat but on the lack of sense not unusually found in the children of men. The picture is true, but it is by no means produced only by excessive meat ingestion; the overheating of any rich protein food will produce similar effects. None of these effects need be produced in a normally energetic individual who eats rich protein foods in moderation, includes liberal amounts of milk, fruits and vegetables in his diet, drinks plenty of water and prevents protein putrefaction by a normal consumption of sugar.

Consumption of Meat.—If one examines the pre-war statistics of food consumption of the people of Great Britain and the United States of America, one will see certain contrasts and parallels. From the Imperial Economic Committee's Reports on Meat and Dairy Produce, 1937–38, it can be seen that the average weekly consumption of meat, including veal, mutton, lamb, bacon and ham, was 41 oz. per head of the population. The total meat consumption per head per week for the U.S.A. was 42 oz.; Canada 44 oz.; Australia 61 oz. and New Zealand 70 oz. Neither poultry, which constitutes but a small percentage (about 4) of the total meat consumption in the United Kingdom, nor fish is included in these figures. Of these animal products about 50 per cent is home produced. During the war we were able to secure only about 12 to 16 oz. per week of meat, an amount universally regarded as inadequate to satisfy the adult palate, and in view of continuing restrictions on meat consumption, it is well to state what should be, or may be accepted as, an adequate weekly intake of meat. The League of Nations standard of 1935 was 28 oz. of meat, including fish; the Stiebling standard in America was dual, an adequate one of 28 oz. and a liberal one of 44½ oz., made up chiefly of beef, veal and pigmeat. In

the U.S.A. and Canada the consumption of mutton and lamb was 2 oz. per head per week in contrast to 8·7 oz. per head per week in this country. The days of pre-war dietetic liberality having passed and the country having experienced a period of severe restriction of animal proteins, it may be asked, "What should the optimum meat intake be?" Dr. Wright, adviser to the Ministry of Food, gives it as his opinion, that the total meat consumption should be "30 oz. per head per week". "The subdivision of meat between beef, mutton and pigmeat should, however, follow British rather than American food habits, which would place the dietary requirements at roughly 14 oz. of beef, 7 oz. of mutton and 9 oz. of pigmeat per head per week." Of this last amount it is suggested "that two-thirds should be available as bacon and ham and one-third as pork". It will be noted, with some appreciation of the fact, that fish, offal and poultry are excluded from these figures.

Differences in dietary habit, in so far as the animal protein foods are concerned, depend upon several factors. That mutton and lamb as well as beef and veal should bulk largely in New Zealand and Australian consumption to the exclusion, almost, of pigmeat, and that on the American continent, mutton and lamb should suffer even a greater exclusion in favour of beef, veal and pigmeat, must be attributed to ecological and economic factors. In Great Britain in 1938 the consumption distribution was more even, being, for beef and veal 16·77 oz., mutton and lamb 7·74 oz., pigmeat 11·83 oz., or 46, 21 and 33 per cent respectively. If Dr. Wright's suggested amounts of 14, 7 and 9 oz. for beef, mutton and pigmeat, respectively, be accepted, there would, and rightly, be no alteration of the percentage allocations of these foods which would be 47, 23 and 30.

Post-war trends in the consumption of bacon and ham reflect the national taste for these foods. In the first world war Danish supplies were cut off and by 1918 the United Kingdom was importing from U.S.A. not the 1913 Danish quota of 130,000 tons but 500,000 tons of bacon. Previous to the second world war 20 per cent of our bacon was imported from North America, 56 per cent from the Continent. Between 1934 and 1938 the average consumption of pigmeat was 11·8 oz per head per week; during the war this consumption figure was only made possible by a great increase in exportation of bacon from Canada and the U.S.A. Since the war, however, our consumption of pigmeat

has fallen to 3·41 oz. per head per week in 1947; in 1949 it was 3 65 oz. per head per week, 31 per cent of the pre-war figure. During 1950, the importation of bacon and ham showed a remarkable recovery, 243,600 tons being imported, an increase of 75 per cent on the 1949 figure, but still only 64 per cent of the pre-war amount (376,800 tons) Home production is even more indicative of the national taste; from the lowest post-war level of 61,800 tons in 1947, production rose to 195,000 tons in 1950, an increase of 20 per cent over the 1938 figure of 161,720 tons.

In June 1950, previous to the cessation of meat imports from Argentina (July 1950) the dietary intake of beef, mutton and lamb, and pigmeat per head per week was 12, 7 and 4 oz respectively, a total of 23 oz. per head per week These amounts are manifestly far too small. Apart from all considerations, economic and political, which determine government food policy, it may be affirmed without fear of denial, that the health and continued well-being of the people of this country, with its well known vagaries of climate, demand a consumption of beef, mutton and pigmeat (pork, bacon, ham) in terms of edible weight not less than that suggested by Dr. Wright, namely 14, 7 and 9 oz. per head per week respectively. These amounts are minimal; they would supply about 16 g. of animal protein per head per day.

Fish.—To all maritime countries the fishing industry is of paramount importance. This is especially so for Great Britain, where the fishing industry is organized into two largely independent branches—the demersal and the pelagic. Demersal fish consist of gadoid fish—cod, haddock, whiting, saith, ling, hake; flat fish—plaice, halibut, turbot, lemon and Dover soles, dabs, megrim; cartilaginous fish—skate, dogfish; and miscellaneous fish—redfish, catfish, eels, etc Pelagic fish are herring, mackerel, sprats and pilchards.

The approximate quantities of British fish landed in 1948

landed this represents 58 lb. per head per annum, a figure which exceeds all other European countries except Norway (75 lb.) and Portugal (67 lb)

The rich harvest of the sea cannot always be expected to remain so; increased population demands increased supplies of food and, as the fish supplies from one area become less plentiful,

the fisherman extends his range of operations merely to find that new areas do not remain fruitful and soon become less and less profitable. The problem of over-fishing has become further accentuated by the development of new methods, the building of larger ships, with the result that several maritime countries have been forced collectively to consider the problem. Several conventions have been held and most have proved ineffectual because of the refusal of some of the interested governments to ratify the conclusions arrived at. In 1947 it was proposed by the British Government that there should be some limitation of fishing for demersal fish in the North Sea during the years 1948 and 1949. The United Kingdom agreed not to increase fishing beyond 85 per cent of the pre-war figure; Denmark, Sweden and Norway agreed to adopt different mesh and size limits of fish and to control the building of vessels. The British Government has recently invited interested countries to form a permanent commission to meet in 1951.

With regard to pelagic fish the situation is quite different, and in view of the need at present to increase the production of first-class food it is well that it is so. It is authoritatively considered that the herring catch, over one quarter of a million tons, could be more than doubled without endangering the sources of supply. Prior to the first world war catches of 500,000 tons were landed; this quantity is approximately equal to our pre-war import of Argentine meat. The index of potential supply is apparent and accordingly the Herring Industry Board in 1946 set a target of 527,000 tons for 1951.

Of the total fish caught in 1948 about 43·6 per cent was cod, 10 2 per cent haddock, 16 9 per cent herrings, the remainder being made up of mackerel, pilchards, lobsters, etc. White fish are caught in areas near our coasts, off the Faroe Islands and Iceland, and in the more distant Barents Sea, the White Sea, the Davis Straits and Newfoundland waters. Herring are caught in waters around our coasts; the fishing is carried on [illegible] March the [illegible] cu- [illegible] all larly on the West Coast of Scotland, herring may [illegible] the year round.

The average composition of the edible part of non-fatty or white fish is, water 80 per cent, protein 16 per cent and fat 0 5 to 0 4 per cent; in the fatty fish the difference in composition

is due to the high fat content, namely 10 to 15 per cent; protein is changed but little, while the water is reduced to 66–70 per cent. The composition per oz. of the edible portion of various fish is shown in Table 57.

TABLE 57

THE COMPOSITION OF FISH

Values are per oz of edible portion (Callow, 1945)

	Waste	Calories	Protein gm	Fat gm	Calcium mg.	Iron mg	Vitamin A I U	Riboflavin mg	Nicotinic acid mg	Vitamin D I.U
Kippers . .	40	62	5·4	4 5	34	0 6	51	0 09	1 2	250
White fish, Cod, etc . .	45	21	4 5	0 3	7	0 3	0	0 04	0 6	0
Fried fish (white)	0	57	5 3	3 4	24	0 3	0	0 03	0 4	0
Fish paste . .	0	47	3 8	2 5	41	1 7	0	0 02	0 3	0
Herring . . .	30	47	4 5	3 3	28	0 4	42	0 08	1 0	250
Salmon, canned	0	48	5 7	2 8	85	0 4	71	0 06	1 8	170
Sardine, canned	0	84	5 7	6 8	114	1 1	77	0 08	1 3	280

The dietary significance of fish is first as a source of protein, second as a source of vitamins Cod, ling, plaice and halibut as purchased have about 10 per cent of protein, appreciable amounts of calcium, vitamin B_1, riboflavin and nicotinic acid but no vitamin A or D. The roe of cod is very rich in protein, 20 g. per cent, and vitamin B_1, 1 5 mg per 100 g. Fresh herring has the same protein content as fresh white fish, but provides 60 mg per cent of calcium and in virtue of its high fat content is particularly rich in vitamins A and D; it is not, however, rich in vitamin B_1. Demersal fish are chiefly non-fatty; cod, ling and haddock which have about 0 5 per cent, plaice 2 per cent and halibut 5 per cent of body fat. The pelagic or surface fish are generally fatty fish, e g. herrings with 18 per cent, salmon 15 per cent, sprats 13 per cent, sea trout 10 per cent and mackerel 8 per cent of body fat.

Herring show wide seasonal variations in their fat content which is high between January and August and low between September and December. The total landings of fish, demersal and pelagic, contribute in approximate figures 35 grams of protein and 20 grams of fat per head per week to British

dietaries (Lovern, 1944). Herring flesh contains varying amounts of vitamin D, the average being about 850 i.u. per 100 grams; the liver oil of the herring is very rich. It is, however, from the livers of cod that the commercial cod-liver oil is prepared and this contains 100,000 i.u. of vitamin A and 20,000 i.u. of vitamin D per 100 grams (Ministry of Food, 1945) Halibut liver oil, of which relatively small quantities are manufactured, is extraordinarily rich in vitamins A and D, being 100 and 10 times greater for vitamins A and D respectively than for these vitamins in cod-liver oil. Investigations into the whole problem of the potential contribution of fish to the British diet have been assiduously pursued for many years at Government Fishery Research Stations. The importance of this work on the future of the fishing industry and its significance in relation to national health cannot be correctly assessed until all the work has been published. Enough is known of the progress of these researches to say that, if scientific advice is accepted and energetically acted upon, the harvest of the sea will not necessarily be greatly increased, for there is a limit to which any area of the sea can be fished without suffering depletion of its stocks, but it will certainly be made more available to all and that, independently of periods of seasonal abundance and scarcity.

Time alone will tell what the new standards in protein-rich foods will be. But, standards apart, it would appear that milk production should have first priority followed by poultry farming and meat production. The great demand for liquid milk, its high nutritive value and the greater efficiency of milk production compared with meat production would support this. Milk and meat production are further bound up with the problems of the supply of cereals and concentrates for the feeding of cattle. To those engaged in the meat and fishing industries, to the nutritionist and the economist the production and supply of protein-rich foods is an eternal balancing of possibilities and probabilities.

Yeast.—In virtue of its protein and high content of the vitamins of the B complex, yeast, while not a foodstuff in the generally accepted sense of the word, is nevertheless a food supplement of high dietetic value. Yeast consists of numerous small cells which in the mass form a putty-like substance having an alcoholic smell, a somewhat unpleasant taste and a pale grey

appearance. Many types of these cells are present in the air, in the scum or barm which forms on the top of beer during its manufacture. Two kinds of yeast are known commercially, baker's or brewer's and food yeast; the former, generally used by bakers in a wet or compressed state, can be obtained in the dry form in which it can be stored and reconstituted when required by the addition of water; it is known to the biochemist as *Saccharomyces cerevisiae*, has an unpleasant taste and tends to produce gastro-intestinal disturbance; the latter (*Torulopsis utilis*) in powder form is of value therapeutically because it has no bitter taste and is an excellent source of thiamine, riboflavin, nicotinic acid, protein (43 g./100 g.), iron and calcium.

This curious and interesting substance, with a name meaning to ferment or froth, has been known from antiquity and was probably first recognized as one of the factors in the making of bread. When the processes of fermentation first aroused man's curiosity in the baking of bread, he was quite unaware of the millions of yeast cells which surrounded him on every side, even in the air which he breathed. It required centuries of observation clouded with superstition before the art of growing yeast was discovered and centuries again, before, superstition discarded, the art emerged into the highly technical processes upon which its commercial production now depends. Similarly with the manner of its action, much scientific investigation has revealed the yeast cell as a living organism responsible for initiating and maintaining many biochemical activities. Like all living cells yeast contains enzymes—maltase, invertase, zymase. Maltase acts on maltose, the chief sugar in germinating barley or malt, converting it into glucose; invertase splits cane sugar or sucrose into glucose and fructose (fruit sugar) which are then fermented forming alcohol and carbon dioxide. By these reactions the starch of the flour is fermented, forming bubbles of carbon dioxide which are firmly held in the dough Upon baking the dough, the heat of the oven kills the yeast enzymes, stops the fermentation, evaporates the alcohol and by expanding the bubbles of gas causes the dough to rise and to become firmly set in its final form.

Food Spoilage.—" All foods, animal and cereal, are exposed to processes which tend to produce spoilage; during handling and processing enzymic (autolytic) and oxidative changes contribute much to spoilage before bacterial activity

has begun. Fish are particularly subject to ante- as well as post-mortem changes on account of the variable periods they may be kept in vessels before unloading. Bacterial spoilage does not set in until *rigor mortis* has been resolved. Prior to this, changes in pH occur mainly due to the degradation of glycogen to lactic acid, which probably influence the onset of bacterial attack. The glycogen content of newly-caught fish, which varies with the species and the amount of *ante-mortem* struggling, is generally lower than that of fresh meat. As a result the minimum *rigor* pH is relatively high, viz., 6·2 to 6·6 in most species, and nearly approaches the lowest pH (6·5) at which most marine bacteria begin to grow actively. This fact no doubt explains in part why fish is relatively so highly perishable. The halibut is an interesting exception. Its minimum pH has been found to be about 5·6; and it is noteworthy that it 'keeps' extraordinarily well.

"The onset and resolution of *rigor* varies somewhat with species, with the degree of rough handling received and with temperature. For commoner commercial species of 'white' fish, stowed in ice, the period elapsing between catching and the resolution of *rigor* lies between 1½ and 2½ days—cod and haddock emerging sooner than the flat fishes. Whitings, which are notoriously poor 'keepers', appear to be an exception, *rigor* resolving in about one day" (Shewan, 1949).

When fish or meat have been placed in refrigerators at accurately controlled temperatures as low as 14° to 10° F. (− 10° to − 12° C.) then bacterial growth can be inhibited for long periods. On thawing, spoilage proceeds as before. With fish such low temperatures do not prevent denaturation of protein or enzymic rancidification of the fat from proceeding quite rapidly; it is therefore necessary to store at − 4° to − 22° F. (− 20° to − 30° C.) if fish is to be preserved in a practically unaltered condition for long periods, up to 9 months. A brief reference to the dangers to which fish may be exposed before reaching the safety of low temperature storage will suffice to show the need for careful and hygienic handling of all animal food.

When caught the flesh and body fluids of healthy fish are sterile; only the external surface, the gills, the slime and the intestines are rich in aerobic flora. There is no evidence that food poisoning pathogens are members of the normal flora of

fish or that fish suffer from infection due to the *Salmonella* group. The organism *Clostridium botulinum*, the cause of fish botulinism in Russia, has not been found in any of our marine fish. This organism is found in the intestines in about 10 per cent of Caspian sturgeons (Burova *et al.*, 1935; Dobrowsky, 1935). The extent of bacterial infection of fish, particularly trawled as opposed to line-caught fish, is probably due to the dragging of the fish over the bottom mud which in places is heavily infected with bacteria and to the expression of the gut contents amongst the fish during the hoisting of the trawl net on board. This may account for the poorer-keeping qualities of trawled fish compared with line fish (Shewan, 1949). The factors determining the onset and degree of spoilage are numerous—at sea, the environment from which the fish come, the manner in which they are caught and the different methods by which they are handled and stored on board the ship. Under the best conditions of handling and storing in ice, fish will remain reasonably fresh for a period of 12 to 14 days. Since the voyage from Grimsby to the White Sea occupies 5 days and the trawler may remain 14 days on the fishing grounds, approximately 50 per cent of the catch will have been packed in ice for longer than the prescribed period Ice, with its melting point at 32° F. can delay the onset of bacterial growth for about 3 to 5 days, after which growth proceeds unhindered; in 10 days the fish would still be quite fresh but after 10 days the quality would begin to decline rapidly. What is required is to freeze the fish at 30° F, thereby markedly reducing the rate of bacterial spoilage, although not affecting protein de- [illegible] ld only be done by [illegible] ips where filleting [illegible] well as offal could be handled. Considerable attention is being given to the improvement of methods for packing in ice, to obviate the bad effects of pressure and leaching—by melting ice—on quality, weight and appearance of landed fish. This applies to all types of fish both for immediate retail and for storage or preservation by smoking, canning and dehydration (Reay, Cutting, Shewan, 1949).

Food Poisoning.—The term "food poisoning" generally refers to outbreaks of acute illness—sickness, vomiting, diarrhœa—occurring shortly after a meal and affecting individuals

has begun. Fish are particularly subject to ante- as well as post-mortem changes on account of the variable periods they may be kept in vessels before unloading. Bacterial spoilage does not set in until *rigor mortis* has been resolved. Prior to this, changes in pH occur mainly due to the degradation of glycogen to lactic acid, which probably influence the onset of bacterial attack. The glycogen content of newly-caught fish, which varies with the species and the amount of *ante-mortem* struggling, is generally lower than that of fresh meat. As a result the minimum *rigor* pH is relatively high, viz., 6·2 to 6·6 in most species, and nearly approaches the lowest pH (6·5) at which most marine bacteria begin to grow actively. This fact no doubt explains in part why fish is relatively so highly perishable. The halibut is an interesting exception. Its minimum pH has been found to be about 5·6; and it is noteworthy that it 'keeps' extraordinarily well.

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When caught the flesh and body fluids of healthy fish are sterile; only the external surface, the gills, the slime and the intestines are rich in aerobic flora. There is no evidence that food poisoning pathogens are members of the normal flora of

home-canned vegetables not with acid fruits ; the toxin develops in the food before it is eaten, the organism itself does not grow in the affected subject.

Alarming as these facts may appear to be, it must be realized that food poisoning is only an occasional event in this country. Its prevention, however, demands the constant supervision of food production by health authorities, the medical supervision of all who handle food and, that those who cook food should be alive to the dangers of spoilage and, when in doubt, should thoroughly cook the food and so sterilize it, or reject it.

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or communities, due in most cases to infections of the alimentary tract associated with acute inflammation of the lining of the stomach and upper intestine. The bacteria most commonly implicated are those of the *salmonella* group and certain strains of *staphylococci* which have the power to produce enterotoxin, that is, a toxic body within the intestine. Food poisoning may also occur from the presence of zinc, bismuth, lead, copper or arsenic, by the ingestion of poisonous plants, the berries of the deadly nightshade, foxglove or henbane. It may also occur long after the ingestion of food such as milk and its products, the type of infection being typhoid and paratyphoid, Malta and abortus fevers, tuberculosis, diphtheria and streptococcal sore throat. Salmonella and staphylococcal infections are generally caused from contact between the food material and the human subject. Salmonella organisms are known as infective agents in rodents, fowls, ducks, pigs, sheep and domestic animals. Contamination occurs either by contact with infected meat, fish or eggs, or by the faeces of infected rats or mice. During the war many salmonella strains new to this country were introduced by the importation of dried eggs, 10 per cent of samples taken being found to contain these organisms. Eggs may readily be infected by contamination of the shell and by penetration through the pores of the shell of numerous organisms. It is therefore necessary that food should be thoroughly cooked or stored at low temperatures (5° C.) to prevent the growth of infecting organisms (Cruickshank, 1949; Diack, 1950).

As a result of bacteriological investigations it is certain that much of the staphylococcal type of food infection or contamination is due to handling, as in the mincing of meat and fish for the production of brawn, meat jellies, pork pies, fish pastes, etc. In the majority of cases infection is caused by nasal carriers, but septic hands of cooks and milkers and milk from cows with mastitis are likely sources.

Salmonella infections are more often associated with milk, eggs, butter, cream cakes, cheese, pressed beef, imported beef, sausages and smoked fish.

A form of food poisoning not common in this country is that due to the growth of anaerobic organism *Clostridium botulinum*. The spores of this organism are very heat resistant. The organism, which is present in soil, is associated mostly with

home-canned vegetables not with acid fruits ; the toxin develops in the food before it is eaten, the organism itself does not grow in the affected subject.

Alarming as these facts may appear to be, it must be realized that food poisoning is only an occasional event in this country. Its prevention, however, demands the constant supervision of food production by health authorities, the medical supervision of all who handle food and, that those who cook food should be alive to the dangers of spoilage and, when in doubt, should thoroughly cook the food and so sterilize it, or reject it.

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CHAPTER XV

BUTTER, MARGARINE AND EDIBLE OILS

BUTTER

THOMAS MUFFETT in 1665 stated that butter was best "for children while they are growing and for old men when they are declining but very unwholesome betwixt these two ages". In the eighteenth century the best milk in London was obtained direct from cows grazing in St. James's Park. In the nineteenth century the production of milk increased greatly, much of it being used for [illegible] atter, not infrequently [illegible] 1748) "served out by th [illegible] with salt". By the end of the eighteenth century butter production had become an established industry in various parts of England, London getting most of its butter from Yorkshire and East Anglia.

Butter.—The scale of home production of cheese and butter is determined by the success with which the demand of the consumer for liquid milk is met. As long, as at present, the demand outruns the supply of liquid milk, cheese and butter will continue to be heavily imported foodstuffs. Since it requires 2½ to 3 gallons of milk to produce 1 lb. of butter, butter should never, in this country, take precedence to the production of fresh liquid milk. Pre-war figures show that of a total consumption of 7·5 oz. of butter per head per week, 6 9 oz., or 92 per cent, was imported (1937–1938). Of imported butter 50 per cent came from Empire countries, chiefly New Zealand and Australia, the remainder from the Low Countries and the Irish Free State.

Butter is made by mechanically separating the fat or cream from the milk; the cream is cooled, graded into sweet and sour and then by prolonged shaking or churning the fat globules coalesce to form butter. If a ripened cream butter is to be made, a pure culture of the *streptococcus lactis* is added to start the souring processes. The best sweet butter is made directly from unripened or sweet cream. The nutritive value of butter lies in its high content of fat and vitamins A and D.

Butter is not a pure fat in that it contains small amounts of caseinogen and lactose. Most of the water, the protein, lactose and salts are found in the fluid left after the cream or fat has been removed. This fluid—buttermilk—corresponds in composition to the milk from which the cream has been taken and is very nutritious

TABLE 58

COMPOSITION OF BUTTER (EMPIRE IMPORTED) AND MARGARINE

Nutritive Value of War-time Foods, M R C., 1945

per 100 *grams*

	Water per cent	Protein g	Fat g	Calories	Vit A I U	Vit D I U
Butter	15	0 5	82 5	745	4,000	60
Margarine (vitaminized)	14	—	85 3	768	2,000	200
Dripping	1	—	99 0	891	100	30

[illegible]

the highest nutritive value, therefore butter made from the milk of New Zealand cows is to be favoured. During the war a ration of 2 oz. of butter per week over a period of 5 years reflected a fall of 70 per cent in butter consumption which was, however, well balanced by an increase of 100 per cent in margarine consumption. During the post-war period the situation remained fairly stationary until 1948 when there was an increase in the consumption of butter to 4 oz while the margarine consumption varied but little. If the greater consumption of margarine in respect to butter were to continue, it is conceivable that more New Zealand and Australian milk would be diverted to the making of cheese. This would be advantageous in helping to raise our consumption of cheese. More milk might also be utilized for the greater production of condensed and dried milks. The diversion from butter to other milk products would result in an all round gain in nutrients.

MARGARINE AND EDIBLE OILS

Production of Margarine.—Previous to the war, production of edible oils and fats amounted to 16·5 million tons, 10 million tons being derived from vegetable oil seeds, 5 million tons from animal sources and 1 million tons from marine sources. The United Kingdom is the world's largest importer of oils and fats and is the least self-sufficient of all large importing countries, being capable of supplying only 3 per cent of its total requirements.

The most important oils for the production of margarine and compound cooking fat are coconut, palm kernel, groundnut, cotton seed, sunflower and whale oils. The coconut oil is imported from the Polynesian Islands, Ceylon, Indonesia and India; palm kernel oil comes mainly from West Africa, the kernels being collected by the natives and the shells cracked by hand, the industry at its source not lending itself to mechanization; groundnuts, better known perhaps as monkey or pea-nuts, form a most important source of edible oils. Because of the loss of previous sources of supply due to war in the Far East, mechanized production has been developed in East and Central Africa. Cotton seed is used almost entirely for edible purposes the best areas of cultivation being in the U.S.A. and India. Sunflower is grown chiefly in the U.S.S.R., particularly in the Ukraine, where, however, the production is almost entirely taken up for home consumption, which has made it necessary for the United Kingdom to produce sunflower crops in suitable areas of the Commonwealth. Whale oil, the principal source of which is in the Antarctic, cannot be used in liquid form. During the war the whaling industry was almost at a standstill, but to-day its rapid development has necessitated the drawing up of an International Whaling Convention to limit the killing of whales in the sole interest of the survival of the industry. In Table 59 is shown the world production of several vegetable and marine oils and animal fats and in the second part of the Table the chief producing countries.

The oils from all these sources must be refined, deodorized [illegible]

matter responsible for characteristic odours and hydrogenation,

by the catalytic addition of hydrogen to the oil, converts the liquid fat to hard fat. All residues from these chemical processes are used for the production of oil cake for the feeding of cattle. In oil technology the most important of these chemical processes is hydrogenation; so great have been the improvements due to scientific investigation that the whole industry has been revolutionized, it being possible to produce a great variety of different fats by the process of selective hydrogenation. It is here that marine oils with their great variety of fatty acids offer greater scope than other oils such as groundnut oil.

TABLE 59

WORLD PRODUCTION OF EDIBLE OILS AND FATS

('000 *long tons—Oil equivalent*) (Food And Agriculture Organisation, 1950)

Type of Oil/Fat	Pre war Average	1947	1948
Vegetable Oils			
Coconut	1,840	1,771	1,732
Palm kernel	344	300	335
Groundnut	2,204	2,214	2,121
Cotton seed	1,452	1,136	1,289
Palm	679	423	521
Others	3,813	3,946	4,462
Animal Fats (excluding butter)	5,186	4,674	4,772
Marine Oils			
Whale oil	492	325	339
Fish oil	413	197	212
Total	16,423	14,986	16 083

Producing Country	Pre war Average	1948
Europe (excluding U S S R)	2,534	1,662
North America (U.S A , Canada, Newfoundland, Mexico)	2,376	3,852
South America (Brazil, Argentina, Uruguay)	660	828
Africa	1,302	1,358
India, Burma, Pakistan, Ceylon	1,299	1,254
China and Manchuria	2,772	2,245
Others	4,988	4,545
Whaling—all areas	492	339
Total	16,423	16,083

The Nutritive Value of Margarine.—*Before it was fortified by the addition of vitamins A and D, margarine was regarded as inferior to butter in nutritive value.* To-day, with the excellent fortification of margarine, one would expect the matter to have been settled except for the question of superiority of flavour and texture. It has been suggested that butter may have a nutritive value wholly unrelated to its vitamin content and that the vitamin of fortification is not the vitamin of the natural product. Experiments carried out both in this country and in the U.S.A. have shown that animal and vegetable fats are almost completely absorbed from the human intestine provided they are liquid at body temperature—37° C. Absorption of fat decreases as the melting point is raised; for example, 98 per cent of groundnut oil, hardened to melt at 37° C., is absorbed, whereas if the melting point is raised to 53° C. only 79 per cent is absorbed. With regard to butter and margarine, both are almost completely absorbed and in this respect no superiority can be claimed for either. Experiments performed to determine whether or not butterfat was better than vegetable fat in maintaining growth failed to confirm previous evidence that the one was better than the other (Deuel *et al.*, 1944–45). This would mean that the fatty acids of butter have no special part to play in nutrition even of the very young (Smith). The suggestion that there may be some special growth-promoting substance in butter has therefore been shown to be of little practical importance. Experiments carried out in India showed that ghee, melted butterfat, the butter being produced from buffalo's milk, was superior to the highly hardened vegetable oils—vanaspatis—in promoting the absorption of calcium and phosphorus (Chanda, 1949). While it is true that the higher the melting point of the vegetable oil the less efficient it is in promoting growth, the evidence at present would favour the conclusion that there is little difference between the not unduly hardened fat, e.g. margarine, and butter in ensuring the normal absorption of these mineral salts and in promoting growth.

Growth is not unrelated to appetite in that appetite determines in some measure the amount of foodstuffs that may be eaten, particularly under experimental conditions. Deuel, Movitt and Hallman (1943–44) found that butter was not superior to many other fats in promoting growth, contrary to the

findings of Boutwell, Elvehjem, Geyer and Hart (1943) and suggested that flavour might be the factor involved. and his colleagues found that when diacetyl, one of th stances responsible for butter flavour, was added to mar or groundnut oil fed to experimental animals, rats in thi they ate more of the flavoured diet in 18 instances and unflavoured diet in only one instance. There are, ho other factors in the diet besides its fat content which m fluence the amount consumed and therefore the growth animal; one of these may be its carbohydrate content. addition of diacetyl or "butterflavour" to other fats will a great increase in the amount consumed "Butterfla consisted in these experiments of diacetyl, butyric aci monobutyric acid and was used in concentrations of 4 pa million. The "butterflavour" added to the food was efficacious in producing greater food consumption than di alone. When such experiments were carried out upon ch (Leichinger *et al.*, 1948) it was found that margarine was more readily provided it was coloured and served in pa butter; when it was colourless and not in pats the c objected to it. It is obvious, therefore, that in consideri nutritive value of fats chemical composition is not th property which matters; flavour, appearance and text also of importance.

The Absorption of F

systemic blood and so to the fat depôts or directly by the blood to the liver. There are two forms in which fatty m

enter the portal blood stream and pass to the liver. Pr A. C. Frazer and his co-workers have shown that the human subject can absorb not less than 95 per cent gested fat even if the diet be loaded by the addition of 150 g. of fat. Defective absorption of fat may be ass with a deficiency of bile or pancreatic juice, obstruc the lymphatics, gastro-intestinal disturbance, or carboh fermentation.

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and of invisible fat from meats, bacon, ham, eggs, milk and various other foodstuffs. It is the total fat from all sources which as a nutrient has so markedly fallen during the post-war period. Fat which makes food palatable is both visible and invisible, in other words, a palate stimulating meal requires for its preparation good quality beef, milk, eggs and butter or margarine and a good quality cooking fat. It is the invisible more than the visible fat which is so lacking to-day. Given 6 oz. of butter, 4 oz. of margarine, 2 oz. of lard or dripping per head per week and a larger ration of beef, milk and eggs for the non-priority groups, the national sense of well-being would be greatly enhanced Food which pleases the eye, the palate and the sense of smell is naturally much more effective in starting the long train of physiological processes upon which its ultimate digestion depends, than that which excites no interest at all. In the preparation of such food fat plays a very definite rôle, for it increases palatability, by improving flavour and texture, and adds greatly to the nutritive value of the meal.

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The Significance of Fat in the Diet.—Of the three proximate principles—fat, protein and carbohydrate—fat provides twice as much energy as either of the other two; one gram of fat yields 9·3 Calories, one gram of protein 4·2 Calories and one gram of carbohydrate 4·1 Calories. In this country, previous to the second world war, a diet giving 3000 Calories per day contained 130 grams of fat which yielded therefore 1209 Calories or 40 per cent of the total energy value of the diet. During the recent war, fat contributed never less than 37 per cent of the daily energy needs, while in the post-war period the lowest intake of fat was 105·4 grams; to a total of 2880 Calories per day this contributed 980 Calories or 30·4 per cent of the whole. As far as fat is concerned, a fall from 40 to 30 per cent is of no physiological significance; indeed it is generally accepted that where a diet provides 3000 Calories daily, at least 35 per cent of the energy should be supplied by fat.

Fat consumption levels vary markedly according to race, climate and social status. Oriental diets contain surprisingly small amounts of fat; a Chinese coolie, an Indian sweeper or a Japanese labourer may derive only 5 to 10 per cent of his energy requirements from fat, while, in contrast, the Eskimo consumes fat sufficient in amount to provide 50 per cent of his total Calories. None would question such a high dietary requirement of fat in the Arctic, but one may rightly be surprised to learn that in equatorial Africa the healthy, powerful and carnivorous Masai obtain about 46 per cent of their energy from fat (*Orr and Gilks*).

Next in importance as a source of energy is the part animal fats and oils play in supplying the nutritionally important vitamins A and D. In fats and fatty foods the vitamin content varies considerably. Vitamins A and D, while present in animal fats such as butter, are entirely absent from fats of vegetable origin. It is for this reason that vegetable fats are not substitutes for animal fats, and that butter substitutes made from vegetable oils are of no value in this respect unless fortified by the addition of vitamins A and D.

During the summer of 1950 the fat ration varied from 10 to 12 oz. per head per week, being made up of 4 oz. margarine, 2 oz. cooking fat and, on alternate weeks, of 4 oz. and 6 oz. of butter. It should be noted that the total fat in the diet is made up of visible fat, butter, margarine, suet, fatty fish and oils,

content but because of the large part which they play in the diet of most people. The fruit vegetables—tomatoes, cucumber, vegetable marrow, pumpkin, melon—with the exception of the tomato have no appreciable content of vitamin C. Peas, beans and lentils are seeds in the pods of leguminous plants. Dried pulses are not fresh legumes dried after collection, but are varieties which require moisture during their growth but very dry conditions when ripe.

It is indeed surprising that the great variety of vegetable products has not led to a fuller and better use of vegetables in the dietary régime of the people of this country. It is true that vegetables form a rather unconcentrated food and that it is difficult for a man to eat enough to secure his need for proteins, mineral salts and vitamins. It is none the less true that the human stomach and intestine are not adapted to receive and to digest such bulky and unmixed diets as are generally characteristic of vegetarian diets. It is well established that we must secure our first-class proteins from sources other than vegetable, and the best sources of these are milk, cheese, eggs and meat. To expect, in this country with its less than temperate climate, its lack of sunshine and its expensive foodstuffs, to secure a sufficient supply of first-class proteins wholly from vegetables is expecting too much and, if persisted in, will merely deprive the body, both of the growing child and the adult, of the best and most easily assimilated amino-acids, which are to be found in proteins of the highest biological value This in no way condemns the use of, nor detracts from, the value of fruits and vegetables as articles of diet. There is no reason why we should not learn from Canada and the United States of America how to put new life into our menus by the wise use of fruits and vegetables.

Public recognition of the nutritional value of vegetables has undoubtedly increased since 1939, for the acreage under vegetables grown for home consumption increased from 292,000 acres in 1939 to [illegible]

dietary of man since time immemorial. With the exception of wild apples, plums, strawberries, raspberries, blackberries and cranberries, all our fruits are of foreign origin, most having been introduced into this country before the seventeenth century

CHAPTER XVI

VEGETABLES, FRUITS, NUTS

VERY few of our vegetables are indigenous to Great Britain; they were introduced from Europe and Asia during the Roman Conquest, the Tudor and Elizabethan periods, particularly the last when vegetable gardens had become popular in the Netherlands and had aroused a good deal of curiosity and interest in England.

The vegetables richest in proteins are the legumes—beans, peas and lentils. Dried beans and peas contain about 20 per cent, dried lentils 25 per cent, of protein. In this respect they compare favourably with meats in general, but many of their proteins are incomplete; they are not of such high quality as those of the cereals, being deficient in sulphur-containing amino-acids, nor are they so easily digested as the animal proteins. Leafy, fruit and flower vegetables and tubers are of no value as sources of protein. As sources of energy two classes of vegetables are of distinct value; they are the seed vegetables, or legumes, and certain of the tubers, such as potatoes, carrots and turnips. These are the starchy vegetables and are very good fuel foods. Reference has already been made to the mineral salt content of the various vegetables and it has been shown that the legumes, good sources of protein, are also excellent sources of calcium, phosphorus and iron. To secure the best possible supply of mineral salts from vegetables we should select peas (dried or fresh), beans, lentils, cauliflower, carrots, watercress and kale.

Vegetables play a very important part in the supply of vitamins. There are very few vegetables which do not contain *two* out of the three vitamins A, B and C, but the amounts vary considerably. Reference to Table 60 will show the value of the vegetables in comparison with other foods. Carrots, parsley, turnip tops, watercress, kale, spinach and tomatoes are the *only* vegetables richly supplied with vitamin A or carotene. Practically all vegetables have a good content of vitamin B_1. As to vitamin C, the leafy vegetables are good sources, as are also potatoes and turnips, not because of a high vitamin

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Table 60

TABLE SHOWING THE COMPARATIVE VALUE OF CERTAIN VEGETABLES, FRUITS AND NUTS

All Amounts are per 100 grams (Edible Portion)

Vegetables

	Protein g	Carbo-hydrate g	Calories	Calcium mg	Phosphorus mg	Iron mg.	Vit A I U.	Vit B_1 μg	Vit. C mg	Wastage per cent
Leafy Vegetables—										
Brussels sprouts	4 4	4 0	34	27	134	1 2	400	120	100	25
Cabbage	1 5	5 0	26	65	28	1 0	900	75	70	30
Kale	3 9	4 5	34	200	67	2 5	8,000	120	130	30
Lettuce .	1 1	1 6	11	26	42	0 7	4,000	75	15	20
Parsley .	5 2	—	21	325	—	8 0	13,000	120	150	0
Spinach .	2·7	2 5	21	—	—	—	13,000	100	65	25
Turnip tops	2 5	3 5	24	—	—	—	10,000	120	100	25
Seed Vegetables—										
Beans, broad	7 2	9 5	71	30	300	1·1	—	—	30	75
„ French	1 1	2 6	15	33	—	0 7	600	75	10	5
„ runner	1·1	2 6	15	33	—	0 7	600	75	20	25
Lentils	23 8	47 9	287	39	424	7 6	50	450	0	0
Peas (split)	22 1	50 9	292	33	813	5 4	200	450	0	0
Soya bean .	40 4	13 3	426	218	420	6 9	0	660	0	0
Tubers and roots—										
Carrots	0 7	4 9	22	48	45	0 6	10,000	60	10	5
Onions (bulb)	0 9	4 7	22	31	46	0 3	0	30	10	5
Parsnips .	1 7	10 2	48	55	75	0 6	200	120	10	35
Potatoes	2 0	16 2	73	8	56	0 7	0	120	30	25
Turnips	0 8	3 4	17	59	46	0 4	0	35	25	35
Fruit Vegetables—										
Cucumber .	0 6	1 6	9	23	31	0 3	0	45	10	25
Tomatoes .	0 9	2 5	14	13	25	0 4	3,000	60	25	15
Flower Vegetables—										
Asparagus .	2 0	2 4	18	28	39	0 9	700	180	60	80
Cauliflower .	2 4	3 0	22	—	60	0 9	0	100	70	30
Celery . .	0 9	1 2	8	52	35	0 6	0	30	5	25
Watercress .	2 9	0 6	14	222	40	1 6	5,000	120	60	15

Note.—The sole source of vitamin A potency in vegetables and fruits is carotene.

TABLE 60 (*contd.*)

FRESH FRUITS

	Protein g	Carbo-hydrate g	Calories	Calcium mg	Phosphorus mg	Iron mg	Vit. A I.U.	Vit. B_1 μg	Vit. C mg	Wastage per cent
Apples (eating)	0 3	10 5	43	4	6 8	0 3	40	45	5	20
Apricots	*0 6*	*6 0*	*26*	*17*	*21*	*0 4*	*750*	*30*	*10*	*8*
Bananas .	1 1	19 2	77	6	28 1	0 4	80	50	10	40
Blackberries	1 3	5 8	28	63	24	0 0	300	20	20	0
Currants, black	0 9	6 6	29	60	43 2	1 3	90	45	200	0
" red	1 1	4 4	21	86	30	1 2	25	45	45	0
Dates . .	2 0	63 9	248	68	63 8	1 6	—	—	—	14
Figs, dried .	1 0	13 5	58	81	—	1 2	9	0	0	1
Gooseberries	1 1	3 4	17	28	33 9	0 3	—	—	—	1
Grapefruit .	*0 6*	*5 8*	*22*	*17*	*15*	*0 3*	*20*	*70*	*40*	*50*
Greengages	0 8	11 8	46	17	22	0 4	400	45	5	6
Lemon	0 8	3 2	15	107	20 7	0 3	—	—	—	1
Oranges .	0 8	8 5	34	41	24	0 3	300	75	55	25
Peaches .	0 6	9 1	35	5	18	0 4	750	20	10	13
Pears (eating)	0 2	10 4	38	7	9	0 2	10	20	3	25
Pineapples	0 5	11 6	46	12	7	0 4	100	75	20	50
Plums (*Victoria*)	*0 6*	*9 6*	*37*	*11*	*16*	*0 4*	*400*	*45*	*3*	*6*
Raspberries .	0 9	5 6	24	41	28	1 2	70	20	30	0
Rhubarb	0 6	0 9	6	103	21	0 4	—	20	10	25
Strawberries	0 6	6 2	25	22	23	0 7	15	20	60	3

NUTS

	Protein g	Fat g	Calories	Calcium mg	Phosphorus mg	Iron mg	Vit. A I.U.	Vit. B_1 μg	Vit. C mg	Wastage per cent
Almonds .	20 5	53 5	598	247	442	4 2	0	240	0	65
Barcelona .	12 9	64 0	667	170	299	2 9	0	—	0	38
Brazil nuts	*13 8*	*61 5*	*644*	*176*	*592*	*2 8*	*0*	—	*0*	*55*
Chestnut	2 3	2 7	172	46	74	0 9	0	—	0	17
Cobnuts	9 0	36 0	398	44	229	1 1	0	—	0	64
Coconuts .	3 8	36 0	365	13	94	2 1	0	—	0	30
Peanuts	28 1	49 0	603	61	365	2 0	0	900	0	31
Walnuts	12 5	51 5	549	61	510	2 4	0	300	0	36

from the Middle and Near East, the lands of the Mediterranean basin and more recently from the North American Continent. Although large quantities of fresh fruits—apples, plums, strawberries, black, red and white currants—are produced in Great Britain, the supply is far from equal to the demand; it is therefore necessary to import fruit of all kinds and for that purpose the methods employed are refrigeration, quick-freezing, canning and spraying with silicon-organic compounds or coating with thermoplastic polythene, to which may be added the newer developments in the field of rubber-derived films which permit of the wrapping of citrus fruits in a transparent, heat-sealed membrane, retaining colour, taste and nutritional value for many months.

Dried fruits are principally of two kinds, the vine fruits or grapes and the tree fruits, generally grown in orchards. Of the dried vine fruits there are three well-known varieties, raisins, currants and sultanas. Raisins were doubtless discovered by finding that grapes which had been left on the vines and had dried in the sun were palatable. They are produced in Spain, Greece, the Smyrna area of Turkey and Crete, and, as a result of one of the largest irrigation schemes known, in Australia which is now the chief exporter of raisins to the United Kingdom. Currants are dried black seedless grapes; their name is associated with the ancient town of Corinth, commercially important as a seaport as early as the eighth century B.C. The cultivation of currants is an important industry in the Peloponnesus, Australia, South Africa and California. Sultanas are produced in Turkey, Greece, Persia and California.

Of the tree fruits, the better known are figs from the Eastern Mediterranean, dates—like figs naturally dried on the tree—from Iraq, Persia and Northern Africa, prunes—a special variety of plum suitable for drying—peaches and apricots, from France, Spain, Australia, the West Indies and the U.S.A.

It is not unusual in discussing the comparative values of foods to include fruits with vegetables. This is misleading, because fruits, with the exception of dried fruits, such as apricots, dates and figs, have not supplies of minerals and vitamins comparable to those of the vegetables (Table 60). Blackberries, black currants, oranges, strawberries, rhubarb and raspberries are the only fruits which contain substantial amounts

of calcium. Since most fruits are eaten raw, they are amongst the best sources of vitamin C. With the exception of apricots, greengages, peaches, plums, prunes and tomatoes, fruits are not good sources of vitamin A. Together, fruits and vegetables play a very important part in the preparation of menus, just as by their variety they stimulate appetite and digestion. Both, because of their base-forming properties, help to maintain the acid-base balance of the blood in favour of the bases, which is the normal condition of the body fluids. Having little protein and fat, both add to the carbohydrate intake and thus combat intestinal putrefaction, which is rather encouraged by a too free ingestion of meat, bread and fats Intestinal activity is greatly aided by fruits and vegetables, due to the presence of acids, salts and cellulose. Recent calculations on the amount of residue left by fruits and vegetables show that it is by no means so great as has been assumed. Green leaves of cabbage, lettuce, etc., are found to leave a residue which is not more than 3 to 5 per cent of their original weight.

Nuts.—There are many varieties of nuts, the better known of which are: almonds, bitter and sweet, from Spain, Portugal, Italy, North Africa; brazils, grown apparently only in Brazil, in the upper tropical regions of the Amazon river; groundnuts or peanuts, grown in many parts of the world, the oil being almost entirely used for food; hazel nuts from Turkey and Spain; walnuts from France, mostly pickled, chestnuts, eaten to a great extent by the peasantry of France and Italy; hazel nuts from the hedgerows of Britain but cultivated chiefly in Kent.

The fall in the importation of nuts occasioned by the war and now due to continuing demands of the world oil market is reflected in the high prices which nuts command to-day, in some cases three times greater than the pre-war figure. Since 1941 vegetarians have had first priority in the allocation of nuts—cashew nuts, hazel nuts, almonds, walnuts and peanuts—by surrendering meat and bacon coupons. Of some 20,000 tons of nuts imported to-day, 3000 tons are allocated to vegetarians, 16,000 tons to the manufacturing trades, the remainder being available for general consumption.

Most nuts are very rich in fat: Barcelona nuts contain 38 4 per cent, brazil nuts 27 7 per cent, peanuts 34·3 per cent, chestnuts only 2 2 per cent; they are also valuable sources of protein

and mineral salts. Their protein is of high biological value, but because of their fat and cellulose content, they retard digestion. Almonds, peanuts and walnuts contain vitamin B_1; in no others are vitamins found and in all carbohydrate is low. It should, however, be noted that as generally eaten, nuts should not be regarded as rich sources of minerals.

Vegetarianism.—The word vegetarianism, a comparatively recent addition to our language, is descriptive of a mode or habit of living, as old as the ancient faiths of the Orient.

Vegetarianism generally refers to a diet from which fish, flesh and fowl have been excluded; more particularly, it demands the further exclusion of milk, eggs and cheese. The prohibition of fish, flesh, fowl, milk, eggs and cheese from the diet leaves but little choice of foodstuffs from which to satisfy the physiological requirements of an active adult. That the requirements could be satisfied by the use of grains, vegetables, fruits, nuts, honey, sugar and treacle some will deny. The suitability, for the human digestive tract, of a diet consisting of these foodstuffs is certainly open to question. There are but few races and religious sects who live upon such a strict diet; high caste and strictly orthodox Hindus and Trappist Monks are amongst them.

One has heard in the past, and will doubtless hear in the future, a great deal about the virtues of vegetarianism. Numerous publications appear in which animal protein is condemned out of hand, carbohydrates are viewed with suspicion and only the vegetables and coarse grains are regarded with unqualified approval. While making use of scientific knowledge, many writers on vegetarianism omit all reference to the scientific origin of the facts they proclaim, and not a few avail themselves of every opportunity to hold up to contempt the findings of medical scientific investigators. Many of these publications are characteristic of the food faddist.

Realizing these facts one will not be led astray by any suggestions that all the ills that flesh is heir to can be cured by any specific diet. True vegetarianism demands that nothing that is of animal origin be eaten; only that which is derived from plant life must be regarded as fit for human consumption This rules out milk, butter and eggs, and creates the chief difficulty associated with the vegetarian diet, namely to secure an adequate amount of calcium and iron, the fat soluble vitamins

and the complete proteins. The difficulty is immediately overcome by the inclusion within the diet of milk, cheese or eggs. But strictly, anyone who adds but one of these animal foods to the diet is not a vegetarian.

From what has been said it will be readily understood that, apart from the stricter castes of the Hindu faith, the strict vegetarian does not exist. If by vegetarianism one means the greater use of fruits and vegetables in a well-balanced diet of milk, eggs and cheese, then most of us would agree as to the excellence of such a dietary régime. But whatever we eat we have no right to conclude that what is excellent and health-promoting for one is necessarily essential for the well-being of others. There is no single indispensable article of diet, be it meat, cabbage or nuts. When we have all the essentials for body building and the maintenance of health in milk, eggs, whole grains, meat, vegetables and fruit, what reasonable grounds can there be for selecting one to the exclusion of the others? To those who have studied the nutritional needs of the body as a whole and the various means of satisfying them, the stupidity of going to dietary extremes must be apparent. Every foodstuff has its rightful place One must not be misled into interpreting the value of vegetables and fruits only in terms of a favourable percentage content of any one or more nutrients. By no objective standard can the importance, in nutrition, of flavour and lusciousness be assessed or the part played by nutrients in stimulating digestion be determined.

Some False Ideas Concerning Foods.—In the realm of food no less than in other spheres, we find superstition, ignorance, credulity and a lack of a critical spirit, all of which are responsible for the quaint and often absurd statements which one hears concerning foods. There are many who, with a persistence worthy of better things, make experiments, almost daily, upon their digestive functions and arrive at conclusions not only as to what is good or bad for them but for others. It is curious, or perhaps it is not so curious, that people with the least experience are the most prone to dogmatize. Having discovered a certain relation between themselves and some foodstuff, they refuse to keep an open mind and immediately proceed to make pretentious claims for, or dogmatic statements against, a certain type of food. Many, finding that not a few people agree with them, proceed further to publish the

so-called facts, to claim infallibility for themselves and to abuse or disagree with all who will not conform to their manner of thought and action. The great art of advertisement had, previous to the war, deluged the world with the most wonderful array of fanciful facts, based upon evidence of the most ephemeral and imaginative kind concerning the whole function of man as a physiological, sociological and artistic individual. It is a type of propaganda which in the post-war period should either be abolished or rigorously controlled. It is not suggested that there is not a very legitimate use for intensive advertising; one need only look at certain published advertisements by iron, steel and engineering firms to realize that they are the outcome of scientific acumen and research and lead, not only to higher standards of quality in goods produced, but to improved standards of living. What is suggested is that in certain spheres there has been a decided abuse of the art of advertising. When one recalls the numerous pre-war publications on health, revealing truth, half-truth, and a general sprinkling of humbug and nonsense, one would hope, that in a more realistic age, something more in accordance with advancing knowledge would be forthcoming

Amongst many false suggestions, we find the statement abroad that starches should not be eaten with protein, because protein stimulates the secretion of acid in the stomach which it is affirmed stops the digestion of starch. This is altogether unnecessary advice. The acid of the stomach only stops the enzymatic breakdown of starch which is started in the mouth by the salivary enzyme ptyalin. To stop enzymatic digestion of starch in the stomach is merely to prepare the way for its further digestion in the intestine by means of the starch splitting enzyme, amylase. There is no incompatibility between any two starches and the delay in starch digestion in the stomach is quite physiological. To those who wish to reduce their weight, the idea of not mixing starches and proteins is of value, if, when one eats only a protein or starchy meal, one does not increase the usual intake of protein or starches. Unmixed with a liberal amount of sugar or starchy food, the protein of the meal will be more quickly digested by the pepsin and hydrochloric acid in the stomach. There is one fallacy in this connection which must be removed and that is, to digest starches the stomach juices should be alkaline. If the stomach were the only place for the

complete digestion of starches, then its secretion would have to be neither acid nor alkaline, but neutral (pH 6 9–7 0). The salivary digestion of starch by means of ptyalin is carried on in the stomach until the hydrochloric acid, penetrating the salivary mass, destroys the enzyme. Ere this destructive action is complete, usually in half an hour, 80 per cent of the starch may have been converted to maltose. Alkalinity of the gastric secretion is not necessary for no further digestion of the maltose can take place until it reaches the first part of the intestine where the enzyme, maltase, awaits to convert maltose into glucose. In the intestine the pancreatic secretion presents these enzymes lactase, sucrase or invertase and maltase for the particular task of converting lactose (milk sugar), sucrose (cane sugar) and maltose (end-product of starch) into glucose, the only form in which carbohydrate is absorbed into the blood stream.

There are numerous myths concerning food. To take but three. It is often stated "that fish makes brains" because of the presence of phosphorus in it Fish muscle has phosphorus, but more than phosphorus is required for building up brain tissue, and phosphorus is just as well supplied by eggs, milk, cheese, meat and whole grains. Another fallacy is that meat is necessary to build muscle; there is no such thing as special foods for building special tissues. That meat is responsible for the production of physical and mental energy is true; we need only look at the robust physique of certain carnivorous people, but that meat is the one and only source of mental and physical energy is quite nonsensical. That it produces toxins as a result of protein putrefactive processes is another tale All proteins, be they in cheese, milk, eggs or meat, if given suitable conditions, will break down and produce toxins. People who suffer from protein putrefaction in the alimentary tract are usually examples of immoderation in eating protein-rich foods. The results of careless dieting, e.g. unhygienic bowel conditions, should not be attributed to meat or eggs, but to those who have not that modicum of wisdom necessary for the simplest regulation of their own lives.

The old controversy of white versus whole wheat bread has been overdone. Whole wheat contains decidedly more of the mineral salts and vitamins, particularly vitamin B_1, than does the highly-milled article, but whole wheat or wholemeal bread cannot supply all our minerals. Even given a suitable

quantity of wholemeal bread or wholemeal in the diet, and its use is decidedly to be encouraged, it will be necessary to take other foods to bring the mineral salts and vitamins up to the optimum needs of the body; to that end we take milk, eggs, cheese, vegetables, liver and fish. If diets are deficient in calcium, phosphorus and iron then such deficiencies can readily be made good, but one must first know the specific deficiency and the requirements and not rely upon shrapnel-like remedies. Many people are receiving diets deficient in mineral salts, but there are means at their disposal for making good the deficiencies, namely by taking more of the simple foodstuffs which contain them—milk, cheese, leafy vegetables and whole grains. There is no need to have recourse to highly-vaunted preparations, which are usually costly and often lead to an imbalance of nutrients in the diet.

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CHAPTER XVII

DIETARY STANDARDS AND DIETARY PLANNING

DIETARY STANDARDS

The evolution of dietary standards may be said to have begun in the early days of magic and medicine when disease was prevented or cured by the prescribing of specific foods. The earliest example is possibly the cure of night blindness by the use of liver. The various reports on the treatment of scurvy in the seventeenth and eighteenth centuries are but landmarks in the history of dietary planning; not until the middle of the nineteenth century do we find dietary requirements stated in terms of nutrients In 1870 Voit, in Munich, suggested that the correct daily allowance for a man performing moderate work was 118 grams of protein, 56 grams of fat and 500 grams of carbohydrate, this supplied about 3000 Calories. Atwater in U.S.A (1903) considered these requirements to be too low and was the first to maintain that standards must vary with conditions of activity and environment. These standards were based on analyses of diets habitually consumed by men under different conditions of work and therefore were without any scientific foundation as standards of physiological requirement. Chittenden (U.S.A), criticizing standards based on controlled food consumption, suggested that a true standard should be based upon a measurement of protein metabolism and maintained that the requirement for protein could only be determined by a knowledge of the amount of protein which would keep the body in nitrogenous equilibrium. This idea of an equilibrium or balance of intake and output was further applied to calcium. The new method of standardization of requirements had at least the merit of being related to the person and not to his dietary habits.

In 1919 the Royal Society Food (War) Committee, reporting on the food requirements of man, accepted the standards determined by Lusk of Cornell University, U.S A.; these were based on very accurate calorimetric studies of the energy

output of individuals of varying age and weight under controlled experimental conditions. Following upon numerous studies of energy expenditure and of mineral and vitamin requirements by Benedict (U.S.A.), Cathcart (Glasgow), Lusk, Du Bois (U.S.A.) and others, the British Medical Association's Committee on Nutrition (1933) published a report in which they discussed the energy requirements of man in relation to health, weight and working capacity. For the requirements of women and children they adopted Cathcart and Murray's (1931) scale. While at this time no quantitative estimate was made regarding minerals or vitamins, they did suggest that protein should provide 10 to 15 per cent of the total Calories. In the same year (1933) Stiebeling of the U.S. Department of Agriculture published standards for Calories, protein, minerals (Ca, P, Fe) and vitamins A and C, which were related to food. The standard of the National Research Council, Washington, U.S.A., published in May 1941, was an extension of the Stiebeling standard to meet all data presented by more recent scientific work. The theoretical standard allowances to meet the nutrient requirements per head of the population in 1948 are given in Table 61. Since the composition of foods and human nutritional requirements are imperfectly known, the dietary standards or allowances must perforce be equally imperfect. The principle underlying the constitution of a standard of diet is to select those foods which will supply the required Calories and nutrients. Were the actual human requirements for all nutrients known there would be no need to trouble about minimal or basic diets, for the known amounts, in suitable proportion for age, sex, activity and other as yet unknown factors would be both the optimal and minimal requirements and anything less would constitute a deficiency.

As a result of much scientific investigation of the physiological requirements of men, women and children, it is now possible to state in approximate terms the nutrient requirements or allowances of individuals and to calculate therefrom the *weighted average* requirements of a population. Using the National Research Council Recommended Dietary Allowances, 1945, this has been done for the population of the United Kingdom in 1948 (Table 61). Table 61 gives in detail the estimated nutrient requirements per head of individuals according to age groups. In calculating average allowances it has been

TABLE 61

ESTIMATED DAILY NUTRIENT REQUIREMENTS[1] PER HEAD

	Calories	Protein	Calcium	Iron	Vitamin A	Vitamin B_1	Riboflavin	Nicotinic Acid	Ascorbic Acid
Children—		g	mg.	mg	i.u.	mg.	mg.	mg	mg
Under 1 year	100/kg	3 5/kg	1,000	6	1,500	0 4	0 6	4	30
1–3 years	1,200	40	1,000	7	2,000	0 6	0 9	6	35
4–6 years	1,600	50	1,000	8	2,500	0 8	1 2	8	50
7–9 years	2,000	60	1,000	10	3,500	1 0	1 5	10	60
10–12 years	2,500	70	1,200	12	4,500	1 2	1 8	12	75
Girls—									
13–15 years	2,600	80	1,300	15	5,000	1 3	2 0	13	80
16–20 years	2,400	75	1,000	15	5,000	1 2	1 8	12	80
Boys—									
13–15 years	3,200	85	1,400	15	5,000	1 5	2 0	15	90
16–20 years	3,800	100	1,400	15	6,000	1 8	2 5	17	100
Women—									
21 years and over.									
Moderately active	2,500	60	800	12	5,000	1 2	1 5	12	70
Pregnant	2,500	85	1,500	15	6,000	1 5	2 5	15	100
Nursing	3,000	100	2,000	15	8,000	1 5	3 0	15	150
Men—									
21 years and over.									
Moderately active	3,000	70	800	12	5,000	1 5	1 8	15	75
Weighted average requirement[2] based on the above for the population of the United Kingdom —									
1934–38 average	2,590	66	920	12	4,680	1 3	1 7	13	71
1948	2,560	65	910	12	4,650	1 3	1 7	13	71

[1] United States National Research Council Recommended Dietary Allowances, 1945 and 1948

[2] Adults other than expectant and nursing mothers have been classified as moderately active

assumed that adults other than expectant and nursing mothers are moderately active. These recommended daily allowances for specific nutrients form the physiological basis for the planning of dietaries sufficient to maintain optimal health. It was not intended that such standards should be used as an infallible and rigid guide. Much dietary survey work has shown quite clearly that excellent health can be maintained on diets supplying fewer Calories, less protein and even fewer vitamins than the respective amounts enumerated in the N.R.C. dietary standard. Many surveys, to some of which reference has been made, *have shown that for adults the amount of animal protein,* vitamin A and vitamin C, is surprisingly low, and yet, clinically, no evidence of undernourishment has been forthcoming. In the past the results of dietary surveys have been interpreted from standards which were not based on the dietary requirements of normally healthy members of the community examined. The formulation of dietary standards for age, sex, condition of life applicable to the group or community, like the preparation of calibration curves, should precede all dietary surveys; only then can a diet be recorded as adequate or inadequate. The *potentialities for misuse of the "dietary yardstick" are clearly* set forth by the Committee of the Food and Nutrition Board of the National Research Council of the United States of America in "Recommended Dietary Allowances" revised in 1948, which calls for a recognition of their limitations and a proper interpretation of their values. These values have been translated into terms of foods in tables of individual, family and group diets, [illegible] worthy [illegible] ested in [illegible]

DIETARY PLANNING

Numerous experiments in planning diets to meet the theoretical requirements of adults and children have been made, and the results *of the analyses of these diets have shown that,* with the exception of Calories, most of the nutrients exceed the [illegible]

average requirements [illegible] show that [illegible] *per cent of* the total energy is derived from protein, and the

protein intake is higher and the vitamin A is less than the physiological requirement (Table 62). Important in the planning of diets is the finding, that high Calorie diets to be palatable, must have a high protein content, for example, diets giving 4500 Calories may have as much as 120 grams of protein. Dietaries planned for U.S. soldiers in training during 1941–45 have shown similar figures which would tend to support the as yet

TABLE 62

DAILY ALLOWANCES OF NUTRIENTS PER HEAD OF THE POPULATION FROM (1) ANALYSIS OF PLANNED STANDARD DIETS (COLS 2, 3 AND 4), AND (2) PHYSIOLOGICAL DATA, WEIGHTED AVERAGE (COLS 5 AND 6)

1	2	3	4	5	6
Nutrients	1933 British Medical Association	Stiebeling, 1933 Adequate Diet at Moderate Cost	League of Nations, 1935, 1936	National Research Council, U S.A., 1941	United Kingdom, 1948
Energy, Calories	2,760	2,985	2,980	2,775	2,560
Per cent of total Calories from protein	12	11	12	9 5	10 7
Protein, g	84	84	89	66	65
Carbohydrate, g	408	370	384	—	—
Fat, g	88	130	121	—	—
Calcium, g	0 69	1 26	1 30	0 91	0 91
Phosphorus, g	1 32	1 58	1 59	—	—
Iron, mg	15	14	13	12	12
Vitamin A, i u	5,346	7,909	6,656	4,696	4,651
Vitamin B_1, mg	0 406	—	0 580	0 516	1 3
Vitamin C, mg	91	126	114	71	71
Riboflavin, mg	—	1 74	—	2 3	1 7
Nicotinic acid, mg	—	—	—	15 5	13

unexplained desire for increased protein where high Calorie diets are a necessity. It further emerges that in assessing the suitability of diets certain requirements must be fulfilled; the Calories from protein should form 10 to 12 per cent of the total Calories available and certain nutrients should bear a definite relation to the energy value of the diet. The factual basis of these statements appear in Table 63, where it is shown that the percentage energy derived from protein is, for bread cereals about 18, milk 21, cheese 28, potatoes 10, dried beans and peas

26, tomatoes and citrus fruits 8 to 13, leafy green vegetables 13 to 35, bacon and meat 25, white fish 95, and eggs 32 (Leitch, 1944).

TABLE 63

SPECIFIED CONSTITUENTS IN FOODS COMPARED WITH AVERAGE ALLOWANCES PER 100 CALORIES, CALCULATED FROM N R C. STANDARDS

(I. Leitch, 1942, *Nut. Abs. and Rev.*)

	Protein, per cent of Calories from	Calcium mg per 100 Calories	Iron mg. per 100 Calories	Vitamin A I U. per 100 Calories	Vitamin B_1 I.U. per 100 Calories	Vitamin C I.U. per 100 Calories
N R C allowance	9 5	83	0 43	169	19	2 6
Type of food—						
Cereals, wheat flour, 85 per cent extraction	13	8	0 7	—	30	—
wheat flour, 72 per cent extraction	14	5	0 3	—	8	—
Milk, whole	21	188	0 2	180	23	2
Cheese, whole milk	28	232	0 3	325	2	—
Potatoes	10	15	0 7	—	45	10
Dried beans, peas	26	26	2 0	—	51	—
Tomatoes, citrus fruits	8 to 13	50 to 112	1·2 to 1 7	250 to 4,300	38 to 87	114 to 138
Leafy green and yellow vegetables—						
green	13 to 35	100 to 480	2 0 to 14 0	670 to 20,700	40 to 280	167 to 310
carrots	11	127	1 2	14,700	44	9
Fats, butter	—	—	—	533	—	—
,, lard	—	—	—	—	—	—
,, bacon	7	2	0 5	—	36	—
Sugars	—	—	—	—	—	—
Lean meat, poultry, fish						
meat	15	2	1 0	14	8	—
flatfish	38	10	0 5	75	3	—
white fish	95	26	0 6	—	26	—
Eggs	32	42	1 6	250	31	—

The wide range of possibilities in planning diets is sufficient to show how elastic dietary standards must be. Dietary standards as in Tables 64 to 68 are but suggested optima, the "Calorie criteria" of Table 63, but guides to good selection.

In planning diets regard must be had to the nature of the foodstuffs which form the major part of the dietaries of the people or community concerned. The modern attitude to the whole question of dietary planning is well put by Dr. Leitch. " It is obvious that if the foods supplying the major part of the energy in a diet are of such a composition that they supply also the major part of the requirements for the separate food constituents, protein, minerals and vitamins, it will probably be safe to plan for Calories in the belief that the rest will take care of itself. But if the staple energy supplying foods do not supply the necessary protein, vitamins and minerals in due proportion, then the rest of the diet must be planned to make up the deficit An examination of the composition of common foods and of the proportion in which they occur in common diets shows that, in planning diets, attention must be given, in the first place, to providing calcium and vitamins A and C, since these do not occur in adequate amounts in the staple energy supplying foods. In the second place, in certain circumstances only, vitamin B_1, iron and protein also should receive special attention since they are present in adequate amounts in the staple foods *unless* these are highly processed cereals, or include too high a proportion of sugar and pure fats. These deductions are fully supported by the results of dietary surveys everywhere. The constituents most often and most gravely deficient are calcium and vitamins A and C. Unfortunately the amounts of sugar and of processed cereals used are so high in many areas, especially in the diets of the poor, that deficiency of vitamin B_1 also, in extreme or minor degrees, is thought to be common."

In selecting foods it must be borne in mind that foods vary in quality and nutritive value. Soil and climate determine in a large measure the food value of cereals, fruits, vegetables and animal products; examples of this are numerous. Carrots vary in colour because of their carotene content; a pale carrot may contain 1000 i.u., a red carrot 5000 i.u. per oz.; cheddar cheese, a hard cheese, has 17 micrograms of riboflavin, while a cream cheese may have only 3 micrograms per oz. Early potatoes may have 8 [illegible]
1 mg. of vitamin C [illegible]
vitamin A per pint, [illegible]
more drastic seasonal changes are seen in the vitamin D content

of the body and liver oil of the herring. The over-ripe banana and orange have a lower vitamin C content than that which obtains when the fruits approach maturity. Dried green peas have no vitamin C until they have been made to germinate. Soil, season, storage, variety, maturity, resistance to plant disease all are of importance in determining food values. There is a great need for more information along these lines. The question as to whether the genes or chromosome numbers or both are factors in determining nutritional values, still remains to be answered.

DIETARY PLANNING AND FOOD COSTS

Liberal diets differ from minimal ones in several respects, the most noteworthy of which is the increased amount, in liberal diets, of animal protein, meat, eggs, milk, vegetables and fruits with its concomitant increase in cost.

One of the most important tasks for people of small or moderate incomes is to know how to meet their nutritional needs at as low a cost as possible. It requires knowledge to select the foods best suited for body-building and for the supply of energy. To buy expensively does not necessarily mean that one is buying the best in the physiological sense. This is indicated by the fact that many who eat well suffer from indigestion, overweight and under-nutrition. Simple wholesome foods can be secured for a moderate expenditure, but it is just as true that many of the best foods—good quality proteins in the form of meat, fish and eggs, and mineral and vitamin containing foods in the form of fruit and certain vegetables—are too costly. It is no easy thing to advise just what to buy on a limited income in order to enjoy that range of foodstuffs which will combine palatability with essentials. There is no great difference between satisfying hunger and securing what is necessary to build up a healthy body. The supply of food quantitatively and qualitatively adequate, cannot, in the interests of sound nutrition, be dissociated from such factors as housing, health and general social conditions. The cost of food must always be discussed in relation to nutritive values; body-building values as well as fuel values must be considered.

To secure a diet consistent with health we must select foods to supply :—

(1) *Energy*—Sugar, butter and cooking fats, and cereals.
(2) *Protein*—Milk, cheese, eggs, meat, cereals and legumes.
(3) *Mineral salts*—Milk, cheese, fruits and vegetables.
(4) *Vitamins*—Vegetables, fruits, butter, milk and cereals.
(5) *Fibre*—Vegetables and fruit.

Some foods are most economical for meeting energy requirements, e.g. sugar; others, particularly those which supply animal proteins, are the most expensive; and of those which supply mineral salts, some are expensive and some are cheap. Summarizing the uses of the various foodstuffs and their approximate cost, we have :—

CARBOHYDRATES.—Sugar is cheap or moderate in price and supplies energy, but only energy; starchy foods, also a source of energy, contain varying amounts of mineral salts, vitamins and protein.

FATS.—They are moderate in price, are excellent sources of energy and vitamins, but are without protein or mineral salts.

CEREALS.—While generally cheap sources of fuel and protein, the whole grains contain vitamins of the B group and minerals—phosphorus, calcium and iron.

MILK AND CHEESE.—These are moderate in price, are excellent sources of protein and energy, and are rich in minerals and vitamins

EGGS.—Eggs are expensive; they are excellent sources of protein and energy and are rich in iron and in the vitamins A, B_1, riboflavin, and vitamins D and E.

MEATS AND FISH.—These are more or less expensive sources of protein and fuel; fish is an excellent source of vitamins A and D and, to less extent, of the mineral salts

VEGETABLES.—These are generally moderate in price. The green vegetables furnish little energy but have good supplies of mineral salts. The starchy vegetables, while good sources of energy, are not good sources of mineral salts. Seed vegetables, i.e. beans, peas and lentils, are excellent for calcium, phosphorus and iron and also for proteins. All fresh vegetables contain vitamins A, B_1 and C

FRUITS.—Fresh fruits are expensive seasonal sources of proteins and energy. With the exception of currants, dried figs, blackberries and oranges, they are not sources of the mineral salts. Some are, and some are not, rich in certain of the vitamins. Almost all are rich in fibre. Dried fruits, apples,

apricots, dates, figs, raisins, prunes, are the most economical of the fruits and should be freely used.

In planning an adequate diet at minimum cost it would be necessary to use meat very sparingly, eggs only for cooking and butter and margarine for vitamin A and for flavouring. Fruit should, if possible, be included in the list but its price and availability will depend upon where one lives. For example, in London, which is a very large fruit centre, it is comparatively cheap, while in the North, far from any such centre, it is by no means cheap. When it is possible to increase the amount of money to be spent on food, or as foods become more available, it is wise to buy more milk, cheese, fruits and vegetables. The present consumption of meats, eggs and butter is far too low. The supply and consumption of meat, eggs, bacon and butter require to be restored to their pre-war values if one is to entertain the hope of securing a diet physiologically adequate for all.

Milk, fruits and vegetables are base-forming foods and good sources of vitamins. Apples, bananas, oranges, raisins, legumes and potatoes are all good " alkalinizers " of the body; meat, eggs, breads and cereals are acid-forming foods.

Milk gives a good return for the money spent upon it; it is always unwise to economize on milk. Especially is this so in a low price diet, for it plays a far more important rôle in such a diet than it does in a high cost one. Sugar should be kept at about 12 oz. per head per week, for, used in excess, it spoils the appetite and prevents the eating of those essential foods which are rich in protein, vitamins and mineral salts. If more food can be bought, cereals should be reduced, fruits and vegetables increased and also, if possible, fish, meat and eggs. Sugars need not be increased as there will be sufficient increase in the carbohydrate intake with the increased consumption of fruits. When increasing the animal protein intake, the advance should be from milk and cheese to eggs and finally to meat; that is roughly the increasing order in cost in relation to availability of the biologically valuable proteins. While all cereals are sources of proteins, they should not be entirely depended upon for protein. Milk is the best supplementary food, for it gives the best supply of those amino-acids in which cereals are somewhat deficient.

With regard to fruits, the price of which varies so greatly, it should be remembered that the dried fruits—raisins, dates,

figs, prunes and apples—all having a good mineral content, can perhaps be bought a little more economically than most fruits and therefore should be used as much as possible in a moderate or minimum cost diet. Of the fresh fruits, apples and bananas for energy and blackcurrants, raspberries and oranges for vitamin C are relatively cheap, depending, as always, upon season and place.

With regard to vegetables, potatoes are cheap sources of energy and vitamin C, while carrots, kale, cabbage, turnips and potatoes are cheap sources of mineral salts and vitamins. Whenever it is financially possible to increase the vegetable intake one should not forget that broad beans, peas and lentils are excellent sources of energy, mineral salts and vitamins. Table 60 shows the comparative value of certain of the vegetables in regard to protein, Calories, minerals and vitamins. Higher income groups always tend to provide more protein, particularly animal protein, vitamins and minerals relative to the Calorie value of the diet than the lower income groups, where the chief deficiencies are in animal protein, vitamins A and C, riboflavin and calcium. It is, however, true in this country, and also on the North American Continent, that all the deficient dietaries are not found among the low income groups.

A Guide to Dietary Planning.—In order to plan meals which are both nutritious and palatable, more detailed information is required concerning the art of menu building. The housewife does not buy Calories, proteins and vitamins, but sugar, meat, potatoes and salt, and many other items of a diet before facing the question of the preparation and cooking of a meal for a family more difficult to feed than to describe in terms of man values. Standard allowances in terms of nutrients are of little value to the housewife faced with the problem of feeding two or three healthy children. The problem is essentially one of the quantity and quality of food It is therefore necessary to give guidance in the formation of menus. Much good advice on food planning [illegible] war years by the [illegible] were and still are [illegible] ow how important is a knowledge not only of the constituents but the composition of a meal, the following, quoted from the Ministry of Food *Manual of Nutrition* (1947), may be instructive.

"It is quite common to find that in a factory two 'communal' meals are provided during the morning. The first, let us say, consists of a 'cheese roll' and a cup of tea. Where there is ignorance of nutrition, this could be forgotten or, at least, not considered to be a meal at all. The second might consist of roast mutton, cabbage and potatoes, followed by stewed apples and custard. The nutritional value of these two meals as eaten has been calculated and are:

MEAL 1

Foodstuff	Quantity	Calories	Protein	Fat	Calcium	Iron	Vitamin A	Vitamin B_1	Riboflavin	Nicotinic Acid	Vitamin C	Vitamin D
	oz		g	g	mg	mg	i.u.	mg.	mg	mg	mg	i.u.
Roll[1] . .	3·5	232	8·8	1·1	100	1·8	0	0·21	0·11	1·4	0	0
Butter . .	0·3	65	0	7·3	0	0	150	0	0	0	0	27
Cheese .	2·0	234	14·2	10·6	460	0·4	738	0·02	0·28	0·2	0	8
Tea .	10·0	20	1·0	1·0	30	0	20	0	0	0	0	0
Total meal .	—	571	24·0	20·0	572	2·2	908	0·23	0·39	1·6	0	35

[1] Calculated as bread.

MEAL 2

Foodstuff	Quantity	Calories	Protein	Fat	Calcium	Iron	Vitamin A	Vitamin B_1	Riboflavin	Nicotinic Acid	Vitamin C	Vitamin D
	oz.		g.	g.	mg	mg.	i.u.	mg	mg.	mg.	mg.	i.u.
Mutton .	2·4	225	8·9	21·1	7	1·4	34	0·12	0·12	2·9	0	0
Cabbage .	3·0	21	1·2	0	54	0·9	255	0·06	0·06	0·3	24	0
Potatoes .	4·0	84	2·4	0	8	0·8	0	0·12	0·08	1·2	10	0
Apples . .	3·0	56	0·3	0	3	0·3	12	0·03	0	0·3	2	0
Custard . .	2·0	62	1·8	2·2	70	0	60	0·02	0·06	0	0	0
Total meal .	—	429	14·6	23·3	142	3·4	361	0·35	0·32	4·7	36[1]	0

[1] 60 per cent deducted from cabbage and 50 per cent from potato and apple to allow for cooking losses"

These calculations show that meal 1, which might thoughtlessly be dismissed as a mere "snack," is in many ways of far higher nutritional value than the *hot* meal 2.

(*a*) It provided over 30 per cent more *Calories* ;
(*b*) almost twice as much protein ;
(*c*) four times as much *calcium* and almost as many times as much *vitamin*.

The single nutrient in which the second meal was markedly superior to the first was *vitamin C*. If the cheese roll had included chopped cabbage or watercress or been accompanied by an orange, it would have been in every way a better meal than the meat, vegetables and sweet. This need not always be the case, of course, when "packed" meals are compared with "cooked" meals. Whether it is or not depends on the *quantities* and the nutritional composition of the items chosen for each meal"

If one-third of a pint of milk were added to meal 1 it would with the exception of iron and vitamin C be far superior to meal 2 as is shown by the figures :—

MEAL 1 PLUS ⅓ PINT OF MILK

	Weight oz	Calories	Protein g	Fat g	Calcium mg	Iron mg	Vitamin A I U.	Vitamin B_1 mg	Riboflavin mg	Vitamin C mg	Vitamin D I U
Milk	6 6	120	6 3	7 0	226	0 1	266	0 076	0 04	2 0	2
Total	—	691	30 3	36 0	798	2 3	1174	0 306	0 43	2 0	37

Consideration of these meals emphasizes the importance of milk, butter, cheese and meat in the formation of diets. The "Oslo breakfast", a mid-day school meal composed of foods [illegible] icies of home diets, consisted [illegible] wholemeal biscuit, butter or [illegible] an apple, or orange or raw carrot ; this supplied animal protein, minerals and vitamins and proved to be more efficacious in promoting the health and well-being of children than a big meal of meat and cooked vegetables.

Group Planning ; Hospital Diets.—As an example of group planning Table 64 shows the "target" *diet devised* in order to determine by comparison, the adequacy of diets in fifteen Scottish maternity hospitals surveyed in 1945.

The diet was regarded as possible within the existing conditions of food rationing and supply and as one which would be generally accepted as good. It represented food consumed by the patient; its nutrient content was estimated and is

Table 64

SUGGESTED WEEKLY MATERNITY DIET

From Dietaries in Maternity Hospitals, E. W. H. Cruickshank and C. P. Stewart

Milk	14 pts	Rabbit	4 oz.	Cabbage and greens	12¾ oz
Butter	2 oz	Fish	10 oz.	Carrots	5 oz
Margarine	4 oz.	Sugar	5 oz	Turnips	3¾ oz.
Cooking fat	3¾ oz	Jam	4 oz	Onions	1½ oz.
Cheese	2 oz	Bread and buns	3 lb	Potatoes	2¼ lb.
Eggs	¼ egg	Flour	5 oz.	Beans	5 oz.
Bacon	2¼ oz	Oatmeal	7 oz.	Raisins	1 oz
Meat	7¼ oz.	Oatmeal pudding	2¾ oz	Prunes	2 oz.
Canned meat	2¼ oz.	Semolina	3 oz.	Stewed apples	3 oz.
Meat pie	3¾ oz	Barley	1 oz	Baked beans	3¾ oz
Sausage	2¼ oz	Macaroni	1 oz	Cocoa	1½ oz
Tripe or other offal	4 oz				

Nutrients	Calculated Average Daily Consumption of Nutrients from the Suggested Diet	Recommended Daily Allowance, Food and Nutrition Board, National Research Council	
		Pregnancy	Lactation
Calories	2,546	2,400	3,000
Carbohydrate	298 g.	—	—
Protein	99 g	85 g	100 g
Animal protein	60 g	—	—
Fat	108 g	—	—
Calcium	1 7 g	1 5 g.	2 g
Iron	13 mg	15 mg	15 mg
Vitamin A	3,429 i u	6,000 i u	8,000 i u
Thiamin	1 3 mg	1 5 mg	1 5 mg
Riboflavin	2 4 mg.	2 5 mg.	3 0 mg.
Nicotinic acid	27 mg	15 mg.	15 mg
Ascorbic acid	36 mg	100 mg	150 mg

shown in the Table, where it is compared with recommended allowances of the N.R.C. of the U.S.A. While the diet was arranged for patients in maternity wards and accordingly prescribes two pints of milk daily, very little alteration is required

to make it a suitable example of the dietary requirements of adults; for example, one pint of milk could be replaced by more egg, cheese, fish or rabbit. To get the full value of such a diet requires cooking of a fairly high standard but several hospitals exceeded the "target" nutrient allowances. As a commentary on the difficulties associated with dietary planning to-day the results of the survey were revealing · the difficulty in obtaining total and animal protein, the lack of liver as a source of valuable nutrients; the impossibility of pregnant women and nursing mothers, leading a sedentary life in hospital, "eating" more than 2500 Calories per day; the low figure for the amount of vitamin C ingested With regard to vitamin C, the target figure was 36 mg. per day; the average intake in this survey was 26 mg. per day; the ascorbic acid was estimated in every foodstuff as presented to the patients and the figure therefore represents the average amount of the vitamin taken in cooked food. Recent work in vitamin C has enforced a revision of our ideas as to what is an adequate intake of this vitamin; 36 mg may be regarded as adequate for nursing mothers under hospital conditions and there is no reason why this amount should not be secured within the range of an ordinary diet, it corresponds to about 100 mg per day on the "as purchased" basis since a combined wastage and cooking loss may amount to 60 per cent.

An analysis of the diet of this survey indicated that the chief sources of calcium, iron and the vitamins were ·

Calcium · milk 65 per cent, starchy foods (cornflour, cocoa, semolina, chocolate mould, rice) 9 per cent; broths and soups 4 per cent; cheese 2 per cent.

Iron: bread 19 8 per cent; meat 8 3 per cent; porridge 7·3 per cent, milk 6 4 per cent, eggs 6 1 per cent; potatoes 5 4 per cent

Vitamin A: milk 30 7 per cent; margarine 11·8 per cent; carrots 8 6 per cent, eggs 8 1 per cent; butter 5 5 per cent

Vitamin C: milk 39·1 per cent ; potatoes 27 2 per cent; cabbage 10 6 per cent; broths and soups 9 4 per cent.

No oranges were given in this diet.

In view of what has been said with regard to energy and protein requirements of the individual it may be maintained

that all patients in hospitals on a normal diet should receive meals, the nutrients of which should conform to the figures in the table. The main change necessary is to make good the nutrients lost by alterations in the ration of milk. In view of the deficiencies in the vitamins it is clear that supplements of A and D should be given and every attempt made to maintain the amount of vitamin C in the diet during pregnancy and lactation.

To guide effectively in the planning of meals one must know the nutrient content of the foods to be chosen and the reason for the choice. Without such knowledge neither the quantity of the foods required nor the quality of the meal proposed can be accurately known. While it is the duty of the dietitian to plan the menus in accordance with the knowledge gained from such calculations, it is none the less the duty of the physician, surgeon or nutritionist to be prepared to state in exact terms *the amounts of the essential nutrients required by patients in* their care. The planning of diets for men and women living under various conditions of activity, for infants, children, adolescents and elderly people, as well as the therapeutic use of diets, are fully described in text books on dietetics to which references are given.

BUDGETARY AND DIETARY SURVEYS OF LOW INCOME GROUPS

The manner in which diets have been planned in relation to the cost and availability of food during the period of the war has been investigated by numerous Budgetary and Dietary Surveys. These surveys have shown that the great majority of families faced the problems of war-time catering and cooking with initiative, and doubtless they will continue to do so throughout the lean years ahead. In the case of the lowest income groups the problem is always one of real hardship and difficulty in that the purchase of food conflicts with the purchase of other things. In the presence of an inadequate purchasing power, the reciprocal relationship between food, clothing, housing, insurance, recreation, etc., becomes strikingly apparent. The results of these surveys emphasize the urgency of planning for better nutritional and social conditions for the lower income groups of the nation. They reveal how closely the attainment of dietary standards is linked with the purchasing power of low

income groups, for the cost of food cannot be dissociated from the cost of other basic needs.

To decide whether the amount of money spent on food in any family group is sufficient, it is essential to know (*a*) the man value of the group, (*b*) the dietary requirements of the group and (*c*) the cost of the food necessary to meet their requirements. Knowing the cost of the food, one may in very broad terms state what should be the minimal or basic income of the family. In view of the great variations which obtain in rents, rates and taxes, these should not be included in any statement of the basic income.

(*a*) **The Man Value of the Group.**—Man values have generally been stated in terms of Calories, taking as unity 3000 Calories per day, the requirement of a moderately active man; they can also be defined in terms of protein and any other nutrient; the following table shows the factors for energy and protein, the protein requirement being that suggested by Cuthbertson (see Table 65) For all practical purposes, it is

TABLE 65

MAN VALUES FOR CALORIES AND PROTEIN

		Calories	Man Values	Protein g	Man Values
Children	Under 1 year	100/Kg	—	3 5/Kg	—
	1–3 years	1,200	0 40	40	0 53
	4–6 years	1,600	0 54	50	0 66
	7–9 years	2,000	0 67	65	0 86
	10–12 years	2,500	0 83	80	1 06
Girls	13–15 years	2,800	0 93	90	1 20
	16–20 years	2,400	0 80	70	0 93
Boys	13–15 years	3,200	1 07	100	1 33
	16–20 years	3,800	1 27	110	1 46
Women	21 years and over.				
	Moderately active	2,500	0 83	65	0 86
	Pregnant	2,500	0 83	75	1 00
	Nursing	3,000	1 00	95	1 26
Men (61 kg)	21 years and over				
	Moderately active	3,000	1 00	75	1 00
	Sedentary	2,400	0 80	65	0 86

sufficient, in assessing man values, to use the factor 0 65 for all members of the family *under* 14 *years of age* and 1 for all who are 14 years and over. Thus for a family of two parents and three children under 14 years of age, the man value is $2 + (3 \times 0{\cdot}65) = 3{\cdot}95$; for two adults and three children, ages 5, 8 and 11 years, using the factors for energy it is 3·87, for protein 4 41. The approximate energy factor was used in budgetary and dietary surveys carried out by the Aberdeen branch of the Children's Nutrition Council and were found to give a good approximation to the man values calculated by more detailed factors for age groups.

(*b*) **The Basic or Minimal Diet.**—Having decided on the factor for the members of the family, it is necessary to obtain a monetary standard, a figure which will cover the minimal expenditure, rent and taxes excluded, on food, clothing, fuel and light, and household and personal sundries. In assessing the amount of money which should be available for family needs after rents, rates and taxes have been paid, the first and most important consideration is the cost of an adequate diet. It may well be argued that the cost of food determines the standard of living and must therefore bear a definite relation to the basic income. The generally accepted minimal dietary standard is that published by the British Medical Association in 1933, Table 66. The comparative costs (1933 to 1950) of the foods composing this diet show how prices have altered since 1933. The British Medical Association diet priced in Edinburgh, in 1933, was 5s. 10½d.; 1936, 6s. 6d.; 1940, 12s. 6½d. in 1945, 15s. 3½d.; and in 1950, 20s. 5d. The weekly meat allowance in July 1950 was worth 1s. 8d.; if we add to this the cost of 4 oz. of bacon, 8½d., and 4 oz. of liver, 4½d., the total weekly expenditure on meat possible to-day would be 2s. 9d. The meat quota of the B.M.A diet would to-day cost 5s. 9d per week; that is, 3s. worth of meat as prescribed by the B M.A. 1933 diet cannot now be obtained because of rationing restrictions. This means therefore that on the B.M.A. dietary basis the total weekly cost of food to-day would be 20s. 5d. — 3s. = 17s. 5d. Certain of the foods in the B.M.A. diet are not readily obtainable to-day and in some cases cannot be procured at all, therefore the correct estimation of the weekly cost of the diet can only be calculated in the light of the amount of foods available. Table 67 indicates the position; the estimated cost of a

basic diet for an adult male in Aberdeen was 9s. 3d. in 1942, 10s. 7d. in 1945 and 14s. 1d. in 1950. Dr. Schulz has arrived at practically the same conclusion; she estimates that for a single woman the "Basic Needs" diet costs 11s 11¼d. and for a single man 14s. 11¾d. per week (June 1950).

Table 66

COST OF ADULT RATION FOR ONE WEEK SUGGESTED AS ADEQUATE BY THE B M.A.

Based on 50 grams First Class Protein, giving ½ Pint Milk Daily, Man-value 1, with the 1933 B M A, and the November 1940, October 1945, and October 1950 Edinburgh Prices of the Foods included

Food	Weight of Weekly Allowance 1933	B M A 1933 cost	Edinburgh Nov 1940 cost	Edinburgh Oct. 1945 cost	Edinburgh Oct 1950 cost
		s d	s d	s d	s d
Beef	1 lb	0 6	1 4	1 8	2 4
Minced meat	½ lb	0 2½	0 6	0 8	0 8
Bacon	¼ lb	0 3	0 9½	1 2	1 4½
Corned beef	½ lb	0 3	0 8	0 10	1 0
Liver (ox)	¼ lb	0 1¾	0 3½	0 3½	0 4½
Eggs	2 oz	0 1	0 3	0 2	0 4
Cheese	¼ lb	0 3¼	0 6¼	0 6½	0 7
Milk	1¾ pts	0 5	0 7	0 7¼	0 8¾
Fish (cod)	¼ lb	0 1¼	0 4½	0 5	0 5¼
Butter	¼ lb	0 2¼	0 4¾	0 5	0 6
Suet	1 oz	0 0¼	0 0½	0 1¼	0 1
Lard	¼ lb	0 1½	0 2	0 2¼	0 3
Flour or	4½ lb	1 0½	1 1½	1 1	1 2½
Bread	7½ lb	1 0½	1 1½	1 6½	1 11½
Sugar	1 lb	0 2¼	0 4½	0 4	0 5
Jam	¾ lb	0 3¼	0 6½	0 9	1 0½
Potatoes	5 lb.	0 3¾	0 5¾	0 6½	0 9
Peas (dried)	¼ lb	0 1	0 2	0 2½	0 2½
Tea	¼ lb	0 3	0 6¾	0 10	0 10½
Oatmeal	½ lb	0 1¼	0 1¾	0 1¾	0 3
Yeast	1 oz	—	—	0 1½	0 2
Rice	¼ lb	0 0¾	0 1¾	0 1½	0 2½
Syrup (treacle)	½ lb	0 2	0 3	0 4¼	0 5
Cabbage	1 lb	0 1	0 2¼	0 3½	0 3
Beans (butter)	¼ lb	0 0¾	0 1¾	0 1¼	0 2½
Barley	½ lb	0 1	0 1	0 3¼	0 5
Fresh fruit and green vegetables	—	0 7	2 4	2 4	3 1
Margarine	¼ lb	—	—	0 2½	0 2¼
Total weekly cost	—	5 10½	12 6½	15 3¼	20 5

Table 67

A BASIC DIET FOR AN ADULT (MODERATELY ACTIVE)

Foods as Purchased Weekly	Quantity	1942 Cost	1945 Cost	1950 Cost	Calories	Protein g	Fat g	Carbohydrates g	Calcium g	Iron mg	Vitamin A I U	Vitamin B_1 mg	Vitamin C mg
		s. d	s. d	s d									
Milk	2 pts	0 8	0 8	0 10	760	38	40	50	1.36	1.0	1,600	0.52	16
Meat	1 lb	1 0	1 6	1 8	1,100	64	80	—	0.03	16.1	114	0.22	—
Bacon and ham	4 oz	0 6½	0 7	0 8½	448	11	45	—	0.01	1.2	—	0.60	—
Fish (fillets cod)	4 oz.	0 5	0 5	0 6	52	12	0.4	—	0.02	0.0	—	0.04	—
Cheese	4 oz	0 4	0 3½	0 3½	464	28	39	—	1.00	0.8	1,470	0.04	—
Eggs (powder)	2 eggs	0 3½	0 2½	0 9	160	12	12	—	0.06	2.5	988	0.03	—
Fats—													
Butter	2 oz	0 3	0 2½	0 3	422	0.2	47	—	0.00	0.0	2,272	—	—
Margarine	4 oz	0 2½	0 2½	0 2½	872	0	98	—	—	0.4	2,272	—	—
Lard	2 oz	0 1½	0 1½	0 1½	500	—	57	—	—	—	—	—	—
Bread	7 lb	1 4	1 8	1 10	8,064	269	45	1,635	1.69	56.0	—	5.04	—
Buns	10 oz	0 6	0 6	0 7	820	24	20	136	0.31	5	—	0.60	—
Flour	½ lb.	0 1½	0 1½	0 2	784	25	15	173	0.04	2	—	0.2	—
Sugar	½ lb	0 1½	0 2	0 2½	864	—	—	216	—	—	—	—	—
Jam, marmalade	4 oz	0 3½	0 3½	0 5½	284	0.4	—	70	0.03	—	—	0.01	24
Potatoes [1]	7 lb.	0 8	0 8	0 10	1,702	45	—	392	0.23	11.2	—	2.01	472
Oatmeal	8 oz.	0 1½	0 7½	0 3	888	27	20	148	0.13	9.6	—	1.02	—
Cereals	8 oz	0 6½	0 1½	0 11	770	31	6	150	0.08	11.2	—	0.09	—
Vegetables—		1 2	1 6	2 6									
e g —Carrots	4 oz				20	0.8	—	4	0.03	0.4	18,000	0.06	8
Turnips	12 oz				30	1.2	—	7	0.13	1.2	—	0.08	60
Cabbage	12 oz.				60	3.6	—	12	0.15	2.4	2,148	0.18	168
Brussels sprouts	12 oz.				84	10	—	10	0.07	3.6	1,020	0.31	236
Tea	4 oz.	0 6½	0 8½	1 0									
Weekly		9 3	10 7	14 1	19,256	592.2	522	3,003	5.59	125.5	28,864	12.88	948
Per day					2,751	84.6	75	429	0.80	17.9	4,123	1.84	135

Animal protein 27 grams per day.

Wastage: potatoes, 15 per cent; carrots, 11 per cent; turnips, 17 per cent; cabbage, 17 per cent; Brussels sprouts, 17 per cent.

Vegetables are given as examples only and are not necessarily in season.

[1] Or lentils or peas in the form of soups.

Possible additions for an optimal diet—

Food per Week	Quantity	Cost	Calories	Protein g.	Fat g	Carbo hydrates g	Calcium g	Iron mg	Vitamin A I U	Vitamin B_1 mg	Vitamin C mg.
Beef, stewing steak	½ lb	—	470	36	36	0	0.024	8.8	112	184	0
Beef steak	½ lb.	—	720	32	65	0	0.024	8.9	112	184	0
Beef, canned (corned)	4 oz	—	276	20	18	0	0.012	12	0	0	0
Tongue	4 oz.	—	292	21	23	0	0.012	3.6	0	320	0
Liver (ox)	4 oz.	—	160	19	6	5	0.012	15	17,040	456	0

The Family Diet.—In the matter of dietary surveys, the family group is more important than the individual for upon the price of food for family groups or communities can be based the cost of living. In his book "The Human Needs of Labour", Mr. Rowntree regarded an average family as consisting of 5 persons—husband, wife and 3 children under 14 years of age. This is the most practical standard upon which to base data relating to economic and dietary surveys, as also the cost of living of working-class families In 1941, a series of surveys was started at the instigation of Professor Bowley, then Director of the Institute of Statistics at Oxford, to determine the cost of a "Human Needs" diet. Under the supervision of Dr. T. Schulz, surveys were carried out, with one or two exceptions, twice yearly in April and November in Oxford, Reading and London. From the results of these surveys food schedules were made up into experimental meals and every substantial variation that had to be introduced in feeding the family was decided in this way, to make sure that it was possible to transform the foods in the schedule into adequate menus for a family of 5 persons consisting of husband, wife and 3 children aged 5, 7 and 12 years. By means of these experimental menus, which were adapted according to changes in rationing and shortages in accustomed foods, the distribution of nutrients to the individual members of the family was determined. As is readily

understood, in a family the official ration is not strictly adhered to, meals being prepared from the family pool and distributed according to custom, age, individual needs and taste. It was found that the distribution of nutrients within the family group bore a very close relationship to the nutritional requirements as stated in tables published by the Ministry of Health.

A Weekly Diet for Five Persons.—A weekly diet for a family of 5 persons—husband, wife, 2 children aged between 7 and 12 years and 1 child aged 5 years—is shown in Table 68A. This "Human Needs" diet was drawn up as a result of surveys carried out in the spring of 1950 by Dr. Schulz of the Institute of Statistics, Oxford. The total cost of the diet amounted to 51s. 3d., which was 2s. 4d. more than the cost of an equivalent diet in November 1949. The total quantities of food for the family are given in the first column and the price per unit in the second, the outlay on each group of foodstuffs is also stated. The first-class protein foods, the most important in such a diet, tend to absorb a very substantial share of the total expenditure on food. Table 68B shows the sub-division of the total diet into the shares received by each member of the family group and it is clear that the husband obtains the largest portion of the tasty foods while the youngest child consumes more milk than any other member of the family. Of the oranges in this diet, most go, as they should, to the children and in all, the picture, according to Dr. Schulz, is probably a fairly realistic one, a number of the foodstuffs being clearly interchangeable without any serious disturbance in the nutritional balance.

The nutritional intake available from the individual shares is shown in Table 68C for calcium, protein, minerals and vitamins. These intakes should be compared with the standards recommended by the Ministry of Health. It will be noted that the amount of protein ingested is above normal, except for the 2 children aged between 7 and 12 years; if, however, the needs of these 2 children were set out separately it could be shown that the child of 7 may secure its requirement of protein but that the child in early adolescence would not. The same point holds with regard to calcium and indicates the disadvantageous position in which the adolescent was placed during the war. The scheme of rationing for adults and for children of 5 years and over proved during the war to be flexible and allowed of interchanges in the diet within the home which were certainly of

TABLE 68A

A "HUMAN NEEDS" DIET IN SPRING, 1950 *T. SCHULZ*

A *Weekly "Human Needs" Diet for a Family of 5 Persons*

Food and Quantity	Price[1] per Unit	Food and Quantity	Price[1] per Unit
			s d.
(a) Rationed foods	s d	17b Swedes 3 lb 8 oz	0 4
1 Meat 5 lb	1 6	17c Greens[3] 1 lb 8 oz	1 0
2. Bacon . 1 lb 4 oz	2 0	17d Onions 8 oz	0 9
3 Margarine 2lb 13oz	0 10	17e Beetroot 2 lb 8 oz	0 4
4 Cooking fat 10 oz	1 0	Outlay on Group (d)	3 10½
5 Sugar 3 lb 12 oz	0 5		
6 Syrup —	—	(e) Other foods.	
7. Tea 8 oz	3 6	18a Peas, dried . 8 oz.	0 10
8 Cheese 10 oz	0 10	18b Beans, dried 8 oz.	0 10
9 Eggs, shell . 5 eggs	0 3	18c Lentils, dried 8 oz	0 9
10 Cond milk, skmd —	—	19 Rolled oats 2 lb 8 oz	0 7
11 Rice — 1 lb 8 oz	0 9	20. Macaroni 4 oz	0 10
12 Dried fruit[2] 8 oz.	0 10	21 Jam (Plum) 6 oz	1 2
Outlay on Group (a)	19 0¾	22 Cocoa 4 oz	1 3½
(b) Fresh milk		23 Condiments —	1 0
13a Ordinary 18½ pt	0 5	24a Herrings —	—
13b School 5 pt.	free	24b Kippers 2 lb 8 oz	1 0
Outlay on Group (b) .	7 8½	25a Pork sausages —	—
(c) Main carbohydrate foods		25b Beef sausage meat 2 lb 8 oz.	1 1
14 Bread 18lb 4oz	0 5½	26 Oranges 2 lb	0 8
15 Flour 2 lb	0 4		
16 Potatoes 21 lb	0 11½		
Outlay on Group (c) .	8 4½	Outlay on Group (e) .	11 6
(d) Fresh vegetables.		Total outlay . .	51 3
17a Carrots —	—		

[1] The price unit is: eggs, one egg; fresh milk, pint; bread, 1¾ lb loaf; potatoes, ¼ stone, cocoa, ¼ lb, condiments, total outlay; all other foods, lb

[2] Prunes in November 1949, currants in April/May 1950

[3] Cabbage in November 1949, spinach in April/May 1950

advantage to young children and adults but were not infrequently unfair to adolescents who could not obtain priority rations. The most important point in such a diet, apart from its satisfactory Calorie intakes for each member of the family, is the percentage of animal protein obtained by all.

TABLE 68B

B. *Individual Weekly Shares Available in "Human Needs" Diet for 5 Persons*

	Husband	Wife	Child 7–12 years[1]	Child 5 years
(a) Rationed foods				
1 [2] Meat	1 lb 8 oz.	14 oz.	15 oz	12 oz
2 Bacon	8 oz.	3 oz	3½ oz	2 oz
3 Margarine	1 lb.	12 oz	6¼ oz.	4 oz
4. Cooking fat	3 oz.	2 oz	2 oz.	1 oz
5 Sugar	6 oz.	1 lb.	13 oz.	12 oz
7 Tea	2½ oz	3 oz.	1 oz.	½ oz
8 Cheese	5 oz.	2 oz.	1 oz.	1 oz.
9 Eggs	1½ eggs	1 egg	1 egg	½ egg
11 Rice	7 oz	6 oz	4 oz	3 oz
12 Dried fruit	2 oz	2 oz.	1½ oz	1 oz
(b) Fresh milk ·				
13a Ordinary	2 pt	3½ pt.	3½ pt.	5 pt
13b. School	—	—	1⅞ pt.	1⅞ pt
(c) Main carbohydrate foods :				
14. Bread	5 lb. 5 oz	4 lb 10 oz	3 lb 4½ oz.	1 lb 12 oz
15 Flour	12 oz	6 oz	6 oz.	2 oz.
16 Potatoes	7 lb.	4 lb.	3 lb 12 oz	2 lb. 8 oz
(d) Fresh vegetables .				
17b Swedes	1 lb 4 oz	14 oz	8 oz	6 oz.
17c Greens	3 oz	3 oz.	6 oz.	6 oz
17d Onions	3 oz.	2 oz.	1 oz	1 oz
17e. Beetroot	8 oz.	8 oz.	8 oz.	8 oz
(e) Other foods .				
18 Pulses	8 oz.	5 oz.	4 oz.	3 oz
19 Rolled Oats	8 oz	8 oz	9 oz	6 oz
20 Macaroni	—	1 oz.	1 oz.	1 oz
21 Jam	1 oz.	1 oz	1½ oz.	1 oz
22 Cocoa	—	1 oz.	1 oz	1 oz
24b Kippers	12 oz	12 oz	6 oz	4 oz
25b Beef sausage meat	12 oz.	8 oz.	8 oz.	4 oz
26. Oranges	—	5 oz.	9 oz.	9 oz.
Cost	13s 0d	10s 11d.	9s. 9d	7s. 10d

[1] Two children in this age group.
[2] The serial numbers correspond to those in the previous Table.

TABLE 68C

C *Nutritional Requirements and Intake from "Human Needs" Diet*

Nutritional Requirements per Day ·

	Husband	Wife	Child 7–12 years[2]	Child 5 years	M A E[1] of Family of 5 Persons
Calories	3000	2500	2100	1500	3 73
Protein, gm	70	60	65	50	4 43
Calcium, gm	0 8	0 8	1 4	1 3	7 13
Iron, mgm	10	10	13	8	5 40
Vitamin A, Intern Units	3000	3000	3000	3000	5 00
Vitamin B_1, mgm	0 90	0 75	0 95	0 68	4 68
Vitamin C, mgm.	30	30	30	30	5 00

Individual Intake per Day from "Human Needs" Diet (Table 68B):

	Husband	Wife	Child 7–14 years[2]	Child 5 years	Average Intake per M.A E[1]
Calories	3100	2560	2170	1550	3100
Protein, gm	90	75	70	52	82
Calcium, gm	0 8	0 8	0 9	0 8	0 6
Iron, mgm.	19	15	13	9	13
Vitamin A, Intern Units	2450	2030	2180	2000	2200
Vitamin B_1, mgm	2 0	1 5	1 4	1 0	1 6
Vitamin C, mgm	25	29	38	36	33
Animal protein, gm	30½	30½	33	30	37½
of total protein requirements	56 4 %	51 7 %	50 8 %	60 %	54 %

[1] Male Adult Equivalent [2] Two children in this age group

The M A E. of this family in terms of money is 3 94

(c) The Basic or Minimal Income per Man Value per Week of the Group.—This is based on the cost of an adequate diet for the family group. It cannot be too clearly emphasized that while the cost of the diet is the basis upon which the standards of necessity are calculated, the figure given is not to be regarded as the amount of money for which this diet can be secured at all times and in all places. The cost of the basic diet must first be determined for each area or community where such standards are to be applied. The extent to which

the cost of an adequate diet has changed since the British Medical Association published the constituents of an adequate diet has been referred to. Having arrived at a fair cost for an adequate diet, one must decide what percentage this should be of the basic income. It was found in the budgetary and dietary surveys of low income groups in Aberdeen, in 1942, that the families spent from 45 to 60 per cent of their available income on food. The cost of the basic diet was 9s. 0½d. for an adult man per week.

For a family of 5 persons, 2 adults and 3 children under 14 years of age, the average weekly cost of the diet for low income groups was 36s. 8d. in 1942. If 50 per cent of the basic income is spent on food, the weekly cost of which was 9s. per man, then the minimal weekly income should have been £3 12s., that is, 9s. × 2 × 3 95 (man value of the family). In Aberdeen in 1945 the weekly cost of the basic diet was 10s. 7d.; a similar calculation gives the basic weekly income of the group as £4 4s. 8d.; and for 1950, with the diet at 14s. 1d. per week, the basic weekly income should be not less than £5 12s. 8d. These figures are for low income groups. They could with advantage be compared with calculations made for a family of similar structure in the south of England not under low income conditions, where the average food expenditure was 51s. 3d., the cost of the basic diet 14s. 11¾d., and therefore the weekly income of such a group, calculated on a similar subsistence basis, would be 15s. × 2 × 4 = £6 per week.

As the children pass into adolescence the man value for the family rises until in this case it becomes 5, when the basic income would be 14s. 1d. × 2 × 5 = £7 0s. 10d. In lower income groups when adolescents go into employment, difficulties of subsistence generally lessen, but where children pass on to secondary education or adolescents enter universities or technical colleges or are engaged in any kind of full time educational activity the subsistence level of the family as a whole may be seriously reduced.

Man values for expenditure vary with the size of the family. They are slightly higher than those for Calories, the figures for which suffice for all practical purposes and are those used in the above calculations. It must be clearly understood that the figures obtained by this method of calculating a "subsistence level" are applicable only to a particular family group when

the cost of food in the area where they live has been determined (see Table 69). It was emphasized at the time that this method of arriving at a minimal standard of necessity was only applicable to families of four or more persons.

Social conditions in many of the lowest income groups make for almost insurmountable difficulties in buying and cooking an

Table 69

TABLE OF FORMULÆ FOR ASSESSING STANDARDS OF SUBSISTENCE IN FAMILY GROUPS

Unit	*Family*
1 Weekly cost of basic diet = x/-	Weekly cost of basic diet = (x/-) × (man val)
2 Basic income = 2x/-	Basic income = (2x/-) × (man val)
3 Clothing = 0 3x/-	Clothing = (0 3x/-) × (man val)
4 Fuel and light = 0 2x/-	Fuel and light = (0 2x/-) × (man val)
5 Household sundries = 0 15x/-	Household sundries = (0 15x/-) × (man val)
6. Personal sundries = 0 35x/-	Personal sundries = (0 35x/-) × (man val)

In the following examples the Basic Diet costs 14/- per man per week

A Family of 4

1	2	3	4
2 adults, 2 children	2 adults, 1 adol , 1 child	2 adults, 2 adol	1 adult, 3 children
Man value = 3 3	Man value = 3 65	Man value = 4	Man value = 3
1 46 2	1 51 1	1 56 0	1 42 0
2 92 4	2 102 2	2 112 0	2 84 0
3 13 8	3 15 3	3 16 8	3 12 6
4 9 2	4 10 2	4 11 2	4 8 4
5 6 9	5 7 7	5 8 4	5. 6 3
6 16 3	6 17 9	6 19 6	6. 14 7

A Family of 5

1	2	3	4	5
2 adults, 3 children	2 adults, 1 adol 2 children	2 adults, 2 adol , 1 child	2 adults, 3 adol	1 adult, 4 children
Man value = 3 95	Man value = 4 3	Man value = 4 65	Man value = 5	Man value = 3 6
1 55 3	1 60 2	1 65 1	1 70 0	1 50 4
2 110 6	2 120 4	2 130 2	2 140 0	2 100 8
3 16 5	3 18 0	3 19 5	3 21 0	3 15 2
4 11 1	4 12 0	4 13 2	4 14 0	4. 10 1
5 8 3	5. 9 0	5. 9 7	5 10 5	5. 7 5
6 19 4	6 21 2	6 22 7	6. 24 5	6. 17 6

adequate diet, particularly in families where there are many young children. In not a few families, where the gross income is good, the money available to the mother to fulfil her household duties is pitiably inadequate. A full realization of the difficulties which beset many low income families depends upon an up-to-date estimate of the cost of an adequate diet.

Food and Other Expenditure.—In 1937–38 the Ministry of Labour (1940) made a survey of household expenditure in industrial and agricultural areas and in villages in England and Wales. In 1938 Mr. Philip Massey made a survey of the expenditure in higher and middle economic groups, the results of which are shown in columns 2 and 3, Table 70. These surveys indicate quite clearly the distribution of expenditure upon food, clothing, fuel and light, miscellaneous items and rent and rates in middle and better class families. Expenditure is an excellent index of living conditions and it is therefore valuable to compare the results of these surveys with those of Mr. D. Caradog Jones (1934 and 1941) and the subsistence standards in Sir William Beveridge's report on *Social Insurance and Allied Services*. The average figures of these surveys are given in Table 70, columns 7, 8 and 9.

The "Beveridge" subsistence standards are based on the usual expenditure found and not on what may be considered necessary. It is important to bear in mind the date of any survey, and to remember that standards require readjustment in an ever-changing world; noteworthy are the trends in expenditure. Despite an appalling drop in the expenditure on food, rent and rates, as one descends the economic scale the expenditure on these items claims 75 per cent of the total income. Under economic conditions, such as these figures portray, the expenditure most necessary, after food, rent and rates, must needs be on fuel and light. Inadequate clothing demands more heat, just as the inadequate income precludes the purchase of many of the necessities and amenities of life. While in the lower income groups 50 per cent of the total income should be spent upon food, the percentage so spent naturally becomes less as the available income increases. In view of the need for better clothing for all members, and particularly the children, of the lower income groups, the amount spent on clothing should be greater than 10 per cent of the weekly income, rates and taxes excluded The percentage distribution of expenditure on rent

HOUSEHOLD EXPENDITURE

1 Items of Expenditure	2 Income £700 or more (Massey 1942)	3 Public Officials (Massey 1942)	4 Industrial Families (Ministry of Labour 1940)	5 Average Family Surveys (Schulz 1948)	6 Subsistence Standards (Cruickshank 1945)	7 Subsistence Standards (Jones 1941)	8 Subsistence Standards (Beveridge corrected for 1942)	9 Income 20 per cent below Poverty Line (Jones 1934)
A. A COMPARISON OF WEEKLY EXPENDITURE IN DIFFERENT ECONOMIC GROUPS								
	s d	s d	s d	s d	s. d	s d	s d	s d
Rent and rates	34 10	21 1½	10 10	12 7	10 6	8 6	10 0	8 9
Food .	64 7	41 10	34 1	57 8	39 6	30 8	24 1	17 1
Clothing	26 7½	15 6	8 1	11 4½	13 9½	11 1	5 0	1 6½
Fuel and light .	16 2	10 1	6 5	0 6	7 11	5 4	4 5	4 0
Miscellaneous .	179 6	83 7	25 7	35 2	17 9½	13 5	7 0	2 6½
Total .	321 8½	172 1½	85 0	126 3½	89 6	69 0	50 6	33 11
Average number of persons per household .	3 97	3 27	3 77	4 6	5 0	5 0	3 77	6 18
B PERCENTAGE DISTRIBUTION OF EXPENDITURE								
Rent and rates .	10 8	12 3	12 7	10 1	11 7	12 3	19 8	25 8
Food . .	20 1	24 3	40 1	45 7	44 1	44 5	47 7	50 4
Clothing . .	8 3	9 0	9 5	9 0	15 4	16 7	9 9	4 5
Fuel and light	5 0	5 9	7 6	7 5	8 8	7 8	8 7	11 8
Miscellaneous . .	55 8	48 5	30 1	27 7	20 0	18 7	13 9	7 5
Total . .	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
C. PERCENTAGE DISTRIBUTION OF EXPENDITURE RENT AND RATES BEING DEDUCTED								
Food . . .	22 4	27 7	45 9	50 8	50 0	50 6	59 0	67 9
Clothing .	9 3	10 2	10 9	10 0	17 5	18 1	12 1	6 1
Fuel and light .	5 6	6 7	8 8	8 4	10 0	8 0	11 0	15 9
Miscellaneous . .	62 7	35 4	34 4	30 8	22 5	22 4	17 3	10 1
Total . .	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0

and rates, food, clothing, fuel and light and household and personal sundries (i.e. miscellaneous items) is shown in Table 70B. Since rent and rates vary considerably it is advisable to deduct these from the total income and this has been done in presenting the percentage expenditure distribution in Table 70C.

In comparing various standard scales for relief benefits two points are noteworthy; first, basic or net incomes should not include rent and rates: rents, varying greatly, and better housing, involving the payment of higher rents, should not be allowed to encroach upon the limited purchasing power of a net income; second, it is imperative in dietary surveys that the composition of the family be considered. Practical standards or "yardsticks" must naturally be flexible; the crucial test would appear to be the manner in which they measure the needs of families of four or more persons. The family most suitable for testing standards consists of father, mother and three children. For adults living alone, for groups of two adults, and families of one adult and one child, monetary additions to the suggested scales must be made according to the circumstances of the case. In low income families a well balanced budget should not be regarded too highly. Families on or below the basic income rates as exemplified in Table 69 are, if not in debt, never very far from it. Theirs is a very precarious existence; if they approach a good expenditure on food, it is certainly at the expense of clothing and other essentials. Debt is rarely, if ever, due to any undue expenditure upon food This method of investigation, namely, by the use of a monetary standard based on the cost of an adequate diet and on factors for determining the minimal expenditure within the family should be of some value to Education Authorities, Public Assistance and other bodies, in deciding conditions of necessity where consideration is being given to the issue of free milk, meals, boots and clothing and in determining the extent and distribution of bursaries, scholarships and grants to boys and girls of ability in schools.

From intimate knowledge of the living conditions of men, women and particularly children, the opinion grows ever stronger that instruction in the elementary principles of healthful living should be an integral part of our educational system. By this is meant that all children should be taught the elements of hygiene, the nutritive value and comparative cost of the chief

foods, how to cook them so that essential nutrients should not be damaged, and should learn something of the elementary physiological needs of the body for growth and the maintenance of health. It is probably not too much to say that this may prove to be a fundamental factor in securing the disappearance of the low income family from our midst. For many parents to-day the feeding of their children is a financial problem which demands courage, selflessness and sacrifice The solution of the problem of national nutrition depends upon an adequate production and equitable distribution of food In the final analysis these are economic problems and, as such, can only be satisfactorily solved when the nutritional needs of world populations are regarded as a whole.

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CHAPTER XVIII

DEHYDRATION AND PRESERVATION OF FOODS

THE preservation of foodstuffs by drying is no new idea. It is part of nature's process in maintaining the living state, as is seen, for example, in grains and the spores of micro-organisms which lie dormant in a state of desiccation until the time of germination by means of moisture has arrived. In America and Africa natives have from the remote past preserved meat by drying it in the sun. The pemmican of the North American Indians, the biltong of the South African natives and the charqui of the South Americans are well known. The dried fruits—apricots, dates, figs, prunes and raisins—have been known from ancient times, as has also been the storing of grain against human need. For centuries fish has been preserved by exposure to sun and wind or by heating. In the Far East the drying of fish is an important industry. On the North Atlantic coasts both fresh and salted cod fish are dried; the fresh wind-dried fish, called "stockfish", is hard and brittle; the heavily salted fish, "klippfish", only partially dried and containing about 40 per cent of water, is comparatively soft. In Great Britain the fish which are dried are gadoids—cod, haddock, whiting, flat fish, plaice, lemon sole, megrim—and fatty fish—herring, salmon, grey mullet. In North American countries the drying of fish is usually associated with heavy salting and smoking. These methods, uncontrolled as to temperature, humidity and time, are productive of a tough texture and strong characteristic flavours which persist after reconstitution and cooking. It can safely be said that none of the dried foods—meat, fish, fruit, milk, eggs and vegetables—in which people are interested to-day have, in the past, possessed qualities which entirely recommended them to the general public. Until recently no intensive research had been undertaken to determine the various conditions under which drying would produce an article of diet, the flavour, nutritive value and keeping qualities of which would be adequately preserved. In 1939, the outbreak of war brought the people of this country face to face with the greatest of all dangers which could confront them, namely the threat of destruction of all imported foods. In view, not only of this

danger, but of the pressing need of shipping space it became imperative that the problem of dehydration of foodstuffs should receive immediate attention. Under the chairmanship of the late Sir Joseph Barcroft, F.R.S., the Food Investigation Board, of the Department of Scientific and Industrial Research, undertook to investigate how best, in the realm of food, to economize in weight, space and labour, and thus help to solve some of the problems of the transport and storage of food in order that the armies abroad, and the people and the armies at home, should be well fed. The work on the drying of food organized by Mr. Eric Barnard, Director of Food Investigation, was conducted under the scientific leadership of Dr. Franklin Kidd, F.R.S., at the Low Temperature Research Station, Cambridge and under Dr. G. Reay, at the Torry Research Station, Aberdeen. The effect of oxygen in causing deterioration of dried foodstuffs was investigated by Dr. Moran and others at the Low Temperature Research Station, by Professor H. D. Kay, F.R.S. and Dr. S. K. Kon at the National Institute for Research in Dairying, Reading, with the co-operation of commercial firms and by Dr. N. C. Wright and Dr. J. A. B. Smith at the Hannah Dairy Research Institute, Ayr, and many others. Dehydration by a vacuum-oil technique has also been achieved by Dr. B. S. Platt of the Human Nutrition Research Unit of the Medical Research Council.

THE PRINCIPLES OF FOOD DEHYDRATION

In chemistry, dehydration is the removal of water from a compound. Freezing may be regarded as dehydration, since the water in the foodstuff has been deposited as ice crystals and can take little or no part in chemical changes which may still proceed at the freezing point. That changes do take place at or below freezing point is indicated by the development of unpalatable flavours in frozen food. These " off " flavours are due to the presence of enzymes or ferments which are not destroyed by freezing. The chief reason for removing water is to prevent bacterial action which may destroy the food, render it unpalatable and even dangerous.

It becomes necessary therefore before freezing to kill the enzymes; this is done by pre-heating, scalding or blanching. The means whereby the frozen water is removed without thawing

is to sublime the ice in a vacuum at $-20°$ C., the vapour condensing on refrigerating coils at a temperature of about $-40°$ C. Foodstuffs dried in this way retain their flavour; keeping qualities, appearance and vitamins. All the principal foods have been experimentally dried *in vacuo*. This method of dehydration was not used on an extensive commercial scale during the war, the development of the necessary industrial plant being largely a peace time project.

Oxygen is a very potent factor in causing deterioration of food, fresh or dried; it must be removed, if not wholly, at least to a very great extent if a foodstuff is to retain its essential qualities for long periods, e g. twelve months or two years. Oxygen can be removed by replacing it with an inert gas such as nitrogen. Anti-oxidants may be added to the dried food or the anti-oxidants present in foodstuffs may be utilized to render dried foods more stable. The action and the use of anti-oxidants have been receiving the attention of food chemists for some considerable time If pre-heating is an initial step in dehydration, the simple air drying procedures can be successfully applied to meat, fish and vegetables The finished product must be packed in an air-tight container, and in nitrogen, if it is to be stored for more than two months. Foodstuffs so prepared are, when reconstituted, characterized by excellent flavour and keeping qualities

In drying it is important that temperature changes be controlled [illegible]
th [illegible]
in [illegible]
and this can be well done by vacuum methods Warmth coupled with humidity enhances bacterial growth; the dried article must therefore be protected from moisture as well as from oxygen To secure the best results in dehydration these principles must be adhered to; and it almost goes without saying that the best in quality, appearance and palatability will never be attained unless the fresh foodstuff is of the best. Dehydration must never be permitted to become a means of marketing foods which, in their fresh state, have so deteriorated that they are not acceptable to the public.

Methods and Apparatus.—Two methods are employed for drying foodstuffs, (1) direct contact with a heated surface and (2) contact with dry heated air (see Fig. 47).

In the first method, the foodstuff may be dried (*a*) in a simple vessel heated by circulating steam, (*b*) in a rotary drier, where the foodstuff is stirred by revolving paddles and (*c*) on rollers, in pairs, heated by steam, the dried material being removed by suitably adjusted knives. In the second method the foodstuff may be dried (*a*) in trays placed in a cabinet or tunnel, through

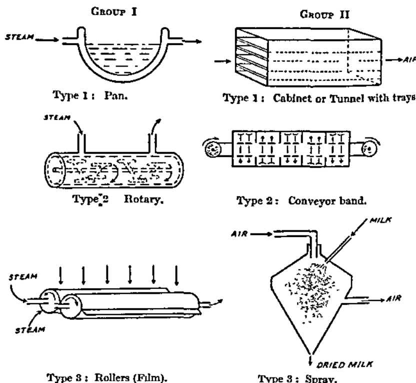


FIG. 47—Methods of dehydration of foods (*after Bate-Smith, Sharp and E M Cruickshank*)

which heated air is passed over the foodstuff, (*b*) on a conveyor band, the warm dry air passing upwards through the foodstuff and (*c*) by spraying liquid foodstuff into a large chamber through which air is forced, the sprayed material being collected at the bottom of the chamber. The method to be used is determined by the nature of the foodstuff to be dehydrated, the temperature being at no time high enough to damage the foodstuff physically or nutritionally.

MEAT

There are many forms of dried meat associated with various countries. The forms best known are biltong, a South African product, and charqui, a South American one. In the production of biltong several methods are employed; lean meat from the legs or loins of beef or game carcases is cut into long thick strips which are slightly cured in a mixture of 38 parts of salt, 1 part of saltpetre and 9 parts of yellow sugar This is sprinkled over the meat which is left to cure for 24 hours; the meat is then hung up and left to dry under cover out of the sun until sufficiently dry for storage. Charqui is produced by cutting large pieces of fresh beef from the carcase; the pieces of meat are cut into strips of roughly uniform thickness, hung up to cool at atmospheric temperatures for about an hour, saturated in salt brine for another hour and finally stacked, covered with coarse salt and left overnight. During the following 2 or 3 days the pile is remade with more salt, the top pieces of meat being placed at the bottom of the new pile. The meat is then finally dried on wooden racks exposed to the sun for an hour or two. It is important in the preparation of charqui that the fat should not melt; the drying is therefore continued under a tarpaulin. This process of curing is continued for several days, depending upon weather conditions, air humidity and temperature, and is finally completed when the meat has lost about 40 per cent of its original raw weight. The final product contains about 20 to 35 per cent of fatty tissue, the best grades having the highest fat content. The lean portions contain 34 to 36 per cent of water and 11 to 13 per cent of salt, while the fatty tissue contains about 4 per cent of water and 1 to 2 per cent of salt. Biltong is a very lean product, charqui a very fatty one. Pemmican is a type of dried meat originally prepared by North American Indians, consisting of strips of lean meat mixed with rendered fat.

Meat can be dehydrated in the raw state or after previous cooking. Raw meat is first of all minced, the mince is dried on wire mesh trays at 2 lb. per sq. ft. in a current of air which at the beginning of the drying should not exceed 70° C. and towards the end should be *not more than* 60° C. *Fully cooked meat*, where the collagen has been converted into gelatine, when dried, is brittle and crumbles to a powder when compressed.

If not compressed it reconstitutes very satisfactorily. If, however, the meat when dried is to be compressed it should be cooked only until it is brown throughout. By this light cooking the collagen is not destroyed and the granules do not break down under pressure.

A standard process for the dehydration of meat has been developed in Britain at the Low Temperature Research Station of the Department of Scientific and Industrial Research. It is now used in New Zealand and Argentina. In this process the raw meat is first removed from the bone, cut into small slices and cooked in open pans in a minimal amount of water or in steam at low pressure, the cooking being only sufficient to brown the meat. It is then coarsely minced, spread on trays and dried in a cabinet (Fig. 47, Group 2, Type 1) at 60°, or at 70°–80° C. under a slight vacuum; it suffers very little loss of nutritive value. Humidity and temperature are controlled. At the beginning of drying the dry bulb temperature is 80° C. and the wet bulb temperature 55° C.; at the later stages of drying the dry bulb temperature is reduced to 70° C.: this prevents scorching of the dried product. The process is generally completed in 5 hours. Temperatures rising higher than 80° C. have a progressively *bad effect upon the biological value of meat proteins*. At temperatures up to 80° C. in the chamber there is no loss of vitamin B_1; above this, for example, at 100° C., the loss may be 70 per cent, while at 125° C. the vitamin is completely destroyed. While these figures represent losses in the drying chamber, it must be noted that the previous heating of the meat for some 15 minutes, until it is brown, causes a loss of from 30 to 50 per cent of vitamin B_1. There appears to be no difficulty in retaining palatability and flavour. To retain a normal texture is a difficult problem. It is best retained by drying in a current of air in a tunnel, or on a conveyor belt. All cooking liquors are collected, concentrated and spread on the drying meat and thus minerals are not lost from the dried product. Riboflavin and nicotinic acid are not apparently affected by drying. The fat content of dried meat ranges from 30 to 40 per cent, this, with the added juices is of value in maintaining the natural flavour of meat. There should not be more than 7·5 per cent of water in the finished product; if the water content be above 17 per cent on a fat-free basis, moulds will grow. Reconstitution and cooking of British standard dried meat present

no difficulties and palatability is excellent, provided the dehydration has been carried out with attention to temperature, moisture and packing. In cooking, the amount of water used should be three times the volume of dried meat. To be assured that dried meat will keep well for a period of twelve months, it must be packed in air-tight tins with all the air replaced by an inert gas If there be any oxidation of fat, the meat may become rancid, moulds may develop and free fatty acids may be formed.

The value of a dried meat product, in the saving of weight and space in the transportation of food in war time, is indicated by the changes in weight and bulk of fresh meat subjected to boning, tinning and drying shown in Table 71.

TABLE 71

SHOWING THE EFFECT ON WEIGHT AND SPACE OF THE VARIOUS METHODS OF TREATING BEEF

(From Sir Joseph Barcroft, F R S)

	Weight (lb)	Bulk occupied (cu, ft)
Side of beef . .	150	6 3
Boned	112	3 0
Tinned .	120	2 6
Dried and blocked .	44	1 0

In terms of shipping space the effect is at once apparent; refrigerated ships required for frozen meat can be dispensed with, and for every three of them required for the transport of boneless frozen meat only one unrefrigerated ship is required for the dehydrated meat, and the amount of water carried is reduced to a negligible fraction of the total weight.

EGGS

Fresh egg pulp contains 13–14 per cent of highly soluble and digestible protein, 11 per cent of fat and about 73 per cent of water. The physical properties upon which depend the lightness in sponge cake, the binding power as well as the retention of moisture are associated with the solubility of the protein, the

foaming capacity of the pulp when beaten and the absence of creaming, that is, separation of the fat on standing.

Eggs have presented difficulties in dehydration. Besides palatability, dried egg powder should retain the physical properties which make eggs valuable in aerating and binding the mixture in making cakes, and in moistening the baked product so that it will keep for many weeks if properly stored. For dehydration eggs are first broken, pulped under good hygienic conditions and the fluid sprayed into the drier (Group 2, Type 3) through which heated air is passed. The temperature of the air is such that the dried powder will have 5 per cent of water, thus temperature and rate of "throughput", as it is termed, are closely related. Important also is the size of the particles of the spray in relation to the length of time they are exposed to the warm air. Numerous experiments on the appropriate temperatures for spray drying have been carried out; some with temperatures varying from 120 to 165° C. have been found not to cause scorching and creaming. This depends, however, upon a low outgoing air temperature; if it be over 68° C., unfavourable flavours appear in the reconstituted product. Many commercial spray driers work on inlet temperatures ranging from 120 to 150° C. and outlet temperatures varying from 50 to 65° C. Spray drying, since it entails the least damage to protein, is the most suitable method for dehydrating eggs. Prolonged drying at temperatures of 50 to 55° C., as in the conveyor belt method, causes a considerable loss of vitamins and so much denaturation of the proteins that their characteristic value in cooking and baking is lost. This, however, does not occur if the egg be spray dried at a temperature between 70°–105° C. There is no appreciable loss of vitamins A and D in spray drying; there is some loss of vitamin B_1.

(2·5–5 per cent) of the dried egg powder and the protection it is afforded against oxidation. If the water content is over 5 per cent and the storage temperature above 15° C., changes begin to take place during storage, which are responsible for the "off" flavours and the poor reconstitution qualities of the powder.

These changes are due to the formation of fatty acids, the breakdown of lecithin and the denaturation of the proteins of the egg, particularly those of the yolk. In the yolk, lecithin and the protein, vitellin, are loosely combined to form lecitho-vitellin On exposure to air or light, lecithins absorb oxygen and water, become darker and more viscid, and like fat, have the property of spreading on the surface of water and forming a film. The formation of fatty acids is therefore associated with the denaturation of the protein. Herein lies part at least of the reason for a failure of the egg powder to behave in cooking exactly in the manner so characteristic of the fresh egg If egg white is beaten, a stiff foam results; this is due to the denaturation of the proteins which form films of solid particles enclosing air bubbles. If this aerating property be destroyed by exposure to too high a temperature, the change becomes evident when the powder is used in cooking. Dried egg is more susceptible to high temperatures than most dried foods. At 37° C. the powder becomes brown and insoluble and has a burnt flavour The moisture content of the dry powder should not exceed 5 per cent, nor should it be less than 2 5 per cent, otherwise deterioration in the flavour takes place. Dried egg should be stored in nitrogen. Mere exclusion of air does not prevent the burnt flavour and insolubility due to high temperatures. Nitrogen is used, not carbon dioxide, because carbon dioxide is rapidly absorbed by the dried egg powder, which results in a risk of air being drawn in before the tin can be sealed. In the tropics, with temperatures approaching or above 25° C. (77° F.), deterioration is much more rapid, and to the changes mentioned are added changes in the carbohydrate of the egg powder. It is well known that carbohydrates hinder the denaturation of proteins which leads to the loss of solubility and aerating power and to creaming. Brooks and Hawthorne have shown that by the addition of 15 per cent sucrose to the egg pulp before drying, a powder with aerating power equal to that of fresh egg can be prepared. Others have suggested that for practical purposes the addition of 13 5 per cent sucrose would result in a product containing 2 parts of egg solids to one part of sucrose. Egg powders, however, which contain sucrose are not suitable for preparing scrambled egg or plain egg dishes but are excellent for use in making cakes, where high aerating or beating power is desired. At present it is impossible, by the strict exclusion

of oxygen and a lowering of the water content of the powder, to prevent these changes taking place at high temperatures. To secure a good quality dried egg powder which will keep for long periods at different temperatures, all the factors mentioned must be carefully considered.

When the war made it impossible for this country to import frozen liquid eggs and glycerinated egg yolks, largely used in baking and manufacture, the Scientific Advisers of the Ministry of Food, after consideration of the nutritive value of various egg powders and the types of plant available for drying eggs, decided to recommend the spray drying process largely used in U.S.A., Australia and South America. The spray drying process played a most important part in our war time economy. So great has been the importation of dried egg powder from the United States and other countries—amounting to almost one hundred thousand tons per annum—that in 1944 and 1945 the great lack of shell eggs was almost made good by the use of the dried product.

The saving in space and weight by dehydration of eggs is very great. The normal egg box contains 360 eggs, the food required to produce these 360 eggs weighs approximately 270 lb. and occupies about 6·0 cubic feet. In shell, 360 eggs weigh 57 lb. and occupy 2·4 cubic feet, as a loose powder they weigh 11 lb. and occupy 0·88 cubic feet, and as a compressed powder weighing 11 lb. they occupy 0·24 cubic feet (Kidd 1944). This means that one ounce of dried egg powder is equivalent to two shell eggs.

One of the most important problems connected with dried egg powder has been to determine a standard of flavour in the dried egg powder prepared for domestic use. To assay the quality of the powder, tasting panels have been formed. These dried egg tasting panels at the Low Temperature Research Station in Cambridge use the following scale or flavour scoring chart. (Bate-Smith, Brooks and Hawthorne, 1943):—

Fresh egg flavour	8 points
Very slightly "off" flavour	7 "
Definitely "off" but not unpleasant	6 "
"Off" flavour and unpleasant	5 "
Increasingly strong and unpleasant	4–3 "
Repulsive and unedible	2–0 "

Trials by tasting panels have shown that the level of acceptance by the domestic consumer is from 6 points upwards on this

scale. A chemical test of quality, based on the fact that deterioration of the egg powder is associated with the production of acid from the glucose of the egg has been suggested by Fryd and Hanson (1945).

MILK

Methods of Drying Milk.—Two types of process are used in the drying of milk, namely, the roller method (drum or film; Group 1, Type 3) and the spray or atomizer method (Group 2, Type 3).

The Roller Method.—In the roller process the milk is distributed as a film on the surface of two steam-heated rollers, thin sheets of dried milk being removed by knife-edged scrapers. The product is sieved to the required fineness of grain. In this method, the temperature of the steam for heating the rollers varies with the rate of rotation of the rollers; at 12 r.p.m., 290° F. is a suitable temperature while at 20 r.p.m. the temperature may be as high as 340° F In vacuum roller drying the rollers are enclosed in a partial vacuum which greatly increases the rate of drying and prevents the milk powder from becoming overheated, with the result that a superior product is obtained compared with that produced by ordinary atmospheric roller drying.

The Spray Method.—Milk which is to be spray dried is previously pasteurised and condensed to about 30–45 per cent total solids. It is sprayed or "atomized" in a drying chamber through which a current of hot air is passed. The air current which enters the drier may be 390° F., in which case the air and the milk spray must be mixed very rapidly. In slower processes the temperature of the incoming air may not be higher than 200° F. The spray consists of minute droplets of milk, exposing a very large surface to the heated air. The result is that the water of the milk droplet is almost instantaneously evaporated, leaving a particle of dried milk spherical in shape, enclosing a correspondingly small bubble of air. The particle is about 0 002 inch in diameter, about one-tenth the size of the flakes of roller dried milk which have to be ground to pass through a sieve of 0 02 inch mesh. The spray dried product is light, the fat is well dispersed and the protein has suffered less change by denaturation because produced at a lower temperature than that of the roller process.

The Composition and Properties of Dried Milk.—The yield of milk powder is about 13 per cent for whole milk and about 9·3 per cent for skimmed milk. This depends upon the total solids in the fresh milk and upon the moisture content of the powder. Where the moisture content is below 4 per cent the lactose of the milk is entirely in the anhydrous form; where powders are stored in conditions of high relative humidity the moisture is rapidly absorbed and the lactose crystallizes.

Differences in the methods of production determine differences in the physical characters of the two products. Roller dried powders are darker in colour and have a more cooked or "caramel" flavour than spray dried. The spray dried powder, having a protein which dissolves readily in cold water and a fat which disperses easily, reconstitutes in a most satisfactory manner. The roller dried milk is not quite so satisfactory; in a whole milk roller dried product the fat globules coalesce and rise to the surface of the fluid and, particularly if the drying has been carried out at a high temperature in air, the solubility of the proteins and therefore their power to form a fine colloidal dispersion is impaired; the solubility is 75 to 85 per cent in cold water (20° C.) and 80 to 95 per cent in hot water (60° C.) Roller drying, if it is to produce a dried milk at all comparable to spray dried milk, must be carried out *in vacuo*. If the milk had been exposed to too high a temperature the poorly reconstituted product will always have a cooked milk taste. A solubility of 75 per cent indicates that most of the protein in the dried milk powder has been rendered insoluble. The percentage composition of dried milk powder varies according as to whether it is made from whole or skimmed milk; to be labelled dried whole milk the powder must contain not less than 26 per cent of fat.

PERCENTAGE COMPOSITION OF MILK POWDER

	Moisture	*Protein*	*Lactose*	*Fat*	*Ash*
Whole milk powder	3	27	37	27	6
Skimmed milk powder .	3	35	53	1	8

To secure good keeping properties, the milk powder should have a moisture content below 3·5 per cent. If it is more than

this the chemical and physical changes which occur affect the protein and lactose, with the result that the powder becomes insoluble, discoloured and develops a stale flavour.

The chief aim in all drying is to maintain good keeping properties in the dried product and good flavour in the reconstituted milk. The keeping properties depend upon the control of oxidations in the dried milk. In 1926 it was observed that butter fat prepared from milk less than 12 hours old was less susceptible to oxidation than fat separated from milk one day old (Holm, Greenbank and Deysher). It was later discovered that pre-heating milk for 30 minutes at 181° F. before drying gave a powder of better keeping properties than that obtained from milk pre-heated to 145°, 163° and 200° F. It is interesting to note that in order to obtain butter resistant to the development of oxidative taints in cold storage, the cream from which it is made should be pre-heated to 165° F. for 30 minutes or, with even better results, to 180° F. for a few seconds, as in the "flash" pasteurisation of milk (Scheib *et al.*, 1942). The pre-heating of milk and its effects on the keeping properties of the dried product have been fully studied by Mattick and several others (1945), who, in comparing the effects of pre-heating at 165° F. and 190° F., state that "the powders prepared from milk pre-heated at the higher temperature remained in good condition, on the average, for two or three times as long as did the powders prepared from milk pre-heated at the lower temperature". It has also been suggested that "the improvement is due to the more efficient destruction of oxidizing enzymes present or produced in the milk by the growth of micro-organisms or the production in the milk of sulphydryl compounds by the action of heat on proteins, particularly the lactalbumin and the protein associated with the fat globules".

Recent work on the preparation of dried milk has been concentrated on two main aspects of the subject: first, methods by which the storage life of whole milk powder can be extended and secondly, the deterioration which occurs in dried skim milk when its moisture content exceeds about 4 per cent. In the first of these two problems the main concern was the prevention of the development of tallowiness in the fat. This has been achieved either by pre-heating the milk to 190° F. for a few seconds before it is dried, or by packing the powder in nitrogen.

The effect of the pre-heating temperature on the bacterial count and storage life of milk powder produced by spray drying processes has been investigated by Findlay, Higginbottom, Smith and Lea who found that with raw milk powder of poor bacteriological quality pre-heating temperatures of 200° and 190° F. greatly reduced the bacterial count in the pre-heated and condensed milks. Lower temperatures produced far less marked reductions. The bacterial counts of the powders produced were low for pre-heating temperatures of 200° and 190° F.; pre-heating temperatures of 170° and 160° F. resulted in powders of relatively high bacterial counts. In the storage tests, spray dried full cream milk powders were prepared from milk pre-heated at 160°, 170°, 180°, 190° and 200° F. for approximately 20 seconds and dried by the Krause process. The milk powders were stored at temperatures of 47°, 37° and 15° C., the storage tests being carried out at two different research institutes, namely the Hannah Institute, Ayr, where the powders were packed in plain tinplate containers, and the Low Temperature Research Station, Cambridge, where the powders were packed in grease-free plain tinplate and lacquered tinplate containers. On storage at room temperature of 15° C., the 190° and 200° F. powders kept for about 5 times and the 180° F. powders for about 3 times as long as the 160° and 170° F. powders. The storage life of the 160° and 170° F. powders was about 4 months while that of the 190° and 200° F. powder was about 22 months; the authors attribute this to the possibility of an adverse effect upon the powder as a result of the relatively high copper content of the containers.

The deterioration on storage of dried skim milk has been investigated by Henry, Kon, Lea and White. These investigators took 3 spray dried skim milk powders with moisture contents of 2·9, 4·7 and 7·3 per cent (dried for 3 hours in an air oven) or 3·0, 5·0 and 7·6 per cent (dried for 20 hours in a vacuum oven), packed them in air and in almost pure nitrogen in gas-tight cans and stored them at 20°, 28·5° and 37° C. for a period of almost two years. They found little change in the powders of low and medium moisture content except in palatability and gas exchange at the higher temperatures. The powder of the highest moisture content, particularly at the higher storage temperatures, rapidly became unpalatable, discoloured and insoluble; its pH, free amino-nitrogen and soluble lactose

content fell; the amount of sugar attached to the protein and the reducing power of the powder towards potassium ferricyanide increased. Oxygen was absorbed and carbon dioxide was produced They concluded that the chief cause of the deterioration in the powder of high moisture content at high storage temperatures was the reaction involving the free amino groups of the milk protein and they suggest that the reaction appears to be between the protein amino-groups and the potential aldehyde group of reducing sugars. This so-called "protein-sugar reaction" results in the production of "off-flavours" described as mainly "heated" or "caramelized" in the case of gas-packed powders and "stale" or "gluey" in the case of air-packed powders, the latter type of "off-flavour" being the more objectionable. From this and other work it is concluded that "gas-packing extends the life of skim-milk powder for several years without detectable loss in the nutritive value of its proteins. Both the procedures mentioned above are in use commercially; the gas-packing, however, is expensive and it is sometimes difficult to get completely gas-tight cans and keep them gas-tight during storage and handling, so that the pre-heating method is the one which has been more commonly adopted in practice. "The deterioration which occurs in skim milk powder when the moisture content is greater than 4 or 5 per cent is due to some of the amino-groups of the lysine in the protein of the milk powder combining with lactose in such a way that the combination apparently cannot be broken down in the alimentary tract. The result is that the protein decreases in biological value during the storage period, due to its decreased content of available lysine. This problem can be entirely avoided by ensuring that the powder is stored in such a way that its moisture content is not allowed to rise beyond the normal 4 or 5 per cent." (Smith)

The effect of antioxidants when present in dried milk, the antioxidant being added to the pre-condensed milk before spray-drying, has been investigated by Findlay, Smith and Lea (1945). Numerous chemical substances have been investigated —ascorbic acid, gallic acid and its esters (methyl, ethyl, propyl, etc.), citric acid, potassium bisulphite, etc.—the best being ethyl gallate, with ascorbic acid a rather poor second. While it is perhaps disappointing that ascorbic acid has not proved so successful as the gallic acid ester, it may be remembered that

gallic acid itself is widely distributed in nature as a constituent of tannins which are present in many vegetable foods and particularly in tea and are usually considered to be non-toxic.

The destruction of harmful enzymes, the production and addition of antioxidants bear a very definite relation to the change of flavour and taste. The cooked flavour and the boiled taste in the reconstituted powders are extremely difficult to assess. It would appear impossible to obtain a reconstituted milk of excellent keeping properties without introducing some slight change in flavour. There seems to be no doubt that during storage of the dried article the cooked or boiled milk taste tends to decrease in intensity.

The Nutritive Value of Dried Milk.—The nutritive values of spray dried and *in vacuo* roller dried milk are almost the same; both suffer some loss of vitamins. The former loses 10 per cent of vitamin B_1, 20 per cent of vitamin C and the biological value of its protein is at least 95 per cent of the original milk protein; the latter loses 15 per cent of vitamin B_1, 30 per cent of vitamin C and the biological value of the protein is not greater than 90 per cent. Vitamins A and D and riboflavin suffer no loss.

Kon has shown that for all practical purposes well made spray dried milk is just as nutritious and can be used for almost any purpose for which ordinary liquid milk is used.

The Bacteriological Quality of Spray Dried Milk.—One may be inclined to think that since milk has been pre-heated to 190° F and spray dried it should be almost sterile. Milk and milk products which have been heat treated do not contain [illegible]

perature of the pre-heating determines the type and the relative number of the micro-organisms present in the powder. These non-pathogenic organisms—streptococci, micrococci and spore bearing organisms—can be effectively controlled by the same measures necessary in the care of pasteurised fresh raw milk, namely sterilisation of the plant, control of the pre-heating temperature and strict attention to the hygiene of personnel. To spray dry milk after pasteurisation and sell it over the counter would settle almost all the difficulties attendant upon the supply of safe fresh liquid milk. If dried milk is to be advocated,

the raw milk must be pasteurised and the dried milk must be of exceptional bacteriological quality. Naturally dried milk must not be left exposed to the air for long periods; it should be used as soon as possible after reconstitution. To all this might be added, but with much less hope of acceptation, the suggestion, that, with dried whole milk on the market, a suitable reconstituting machine and a refrigerator should be available for all families; this would secure for all a safe and palatable liquid milk.

At present the best method to preserve whole fresh milk is to pasteurise, condense and spray dry it, pack the powder in a tin in the presence of nitrogen (i.e. a gas-pack containing 1 per cent of oxygen in the free-space gas) and seal the tin hermetically *and store at temperatures under 15° C (59° F)*. *This has* been done for some time on a large scale in Canada and the product can be so reconstituted that it is, to many skilled milk tasters, quite indistinguishable from ordinary fresh liquid milk (Lea, Moran and Smith, 1943).

Since milk contains more water than most foodstuffs there is a greater saving in weight by its dehydration than is the case with other foods. A fluid pint of milk, i.e. 20 oz. or 568 ml. weighs 20.3 oz. or 575 grams; dried, it weighs 2 oz. and measures about 80 ml.; the dried powder, if compressed into a firm block, would occupy a space of about 40 to 50 c.c.

Quickly Soluble Milk Blocks.—Reference has been made to the results of compressing dried milk, namely, reduction in space, limiting the exclusion of oxygen and the use of packages in place of tin containers. While there are but few foods which would be generally accepted in the form of tablets or blocks, there is no doubt as to the value of food in such form. As a corollary to dehydration several foods have been made in tablet form for use in the Services. Soup cubes have been known for many years, but the most important addition to the group of block or tablet foods is that devised by de Rousset-Hall and Ingram (1945). Milk blocks were first made by compressing a mixture of milk powder, sugar and butter fat; the block so made did not reconstitute rapidly nor smoothly. To procure a block which would break up easily, would dissolve rapidly in either hot or cold water and would reconstitute perfectly, extra fat, to a total of 20 per cent of the mixture, was added in molten form to the dried milk powder. The large

fat content made it possible to cast the mixture in moulds instead of compressing it by a hydraulic press. On cooling, a continuous phase of fat cemented blocks was obtained. To reconstitute rapidly and well the broken block should be stirred into boiling water. The fat finally selected to be used in cool temperate climates was refined, deodorized cocoa butter, which is colourless, tasteless, odourless and melts at 30° C. The blocks do not crumble and are quite hard. For warmer climates, fat of higher melting point must be used, e.g. refined hydrogenated palm kernel oils and mixtures of these with cocoa butter.

Blocks have also been made in which cocoa, coffee, tea, custard and milk puddings have been incorporated in the dried milk-butter fat mixtures. These blocks keep well if protected from moisture by wrapping in waxed transparent films. (de Rousset-Hall and Ingram).

FISH

The dehydration of fish has its own problems; the chief consideration however is one common to all drying processes, the control of bacterial and enzymic action which is responsible for the development of flavours and odours in the final product associated with an alteration in the original protein structure of the fish. During the first world war, experiments had been made in drying chopped fish in a vacuum (Falk 1919). The rapid drying of macerated cooked fish between steam heated [illegible]

porting the maximum amount of food in the minimum amount of space during the second world war, led to intensive research [illegible] ed on a com- [illegible] and his col- [illegible] In selecting the raw material for their work the Torry investigators were of the opinion that lean fish more than any other kind, would yield a product relatively stable to oxidation and the fish they selected were cod, haddock and whiting which contain about 0·3 per cent of lipoids usually amounting to about 1·5 per cent in the dried fish Plaice and lemon sole which contain up to

2·0 per cent of fat were also dehydrated. The success which attended the work on the dehydration of the non-fatty fish, led Dr. Reay to undertake the apparently much more difficult problem of dehydrating fatty fish, e.g. herring and salmon, with an average fat content of 15 per cent. The salmon and herring are subject to wide seasonal variations in their body fat. The highly unstable oils of the fatty fish made it improbable that they could be successfully dried in warm air. It was for this reason that the first experiments were made on lean fish.

Dehydration of Lean Fish.—Since drying in a vacuum at low temperatures was an accepted method with regard to foodstuffs other than fish, the method was accordingly given a full trial. The results with raw fish were not satisfactory. The dried product did not reconstitute well on soaking, the flesh being bleached, spongy and not so glutinous as fresh fish and the taste inferior to that of fresh or frozen fish. It was clear that protein denaturation had seriously affected the reconstituting properties of the dried product. Cooked, minced fish, after "freeze-drying" in this way, could be reconstituted almost unchanged in palatability. This process is not yet, however, a commercial possibility. The practical methods now studied are roller drying and drying in warm air.

Roller Drying.—A small roller drying machine was set up at the Low Temperature Research Station, Cambridge, in which rollers were heated, by steam under 40 lb. pressure per sq. inch, to a surface temperature of 142° C. (287·6° F.). The rollers, moving at a rate of 4½ r.p.m., dried the fish, in a fraction of a minute, to a water content between 5 and 10 per cent. The product was in the form of a lace work of thin white porous ribbons and reconstituted very well, absorbing an amount of water comparable to the water content of the fresh raw fish. There was still some loss of the aroma of perfectly fresh fish.

Air Drying.—For the purpose of dehydrating fish in a current of heated air the semi-automatic kiln described by Hardy and Cutting (1942) for the smoke curing of fish was utilized. The kiln was readily adapted for drying, means being provided for the control of the flow, temperature and humidity of the air, as well as the rate of movement of the trays. Before being passed into the drying chamber, the fish are thoroughly washed, beheaded, skinned and filleted; the flesh is minced, spread on trays to the depth of an inch and cooked for 30 minutes at a

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The dehydration of herrings could now be placed on a commercial basis as a result of the work of Dr. G. Reay and his colleagues at the Torry Research Station, Aberdeen. In selecting the raw material for their work the Torry investigators were of the opinion that lean fish more than any other kind, would yield a product relatively stable to oxidation and the fish they selected were cod, haddock and whiting which contain about 0·3 per cent of lipoids usually amounting to about 1·5 per cent in the dried fish. Plaice and lemon sole which contain up to

to a density of 1 to form firm cohesive blocks that can be made in separate moulds to fit in containers. Dried fatty fish can readily be compressed to firm cohesive blocks but dried lean fish with a water content of 5 per cent cannot be made into cohesive blocks. If the water be raised to about 10 per cent a block can be made and the texture of the fish upon reconstitution does not suffer appreciably. (Reay and Cutting, 1950.)

Reconstitution.—Dehydrated fish being in the form of mince is most suitably reconstituted in the form of made up dishes such as fish and potato pie and kedgeree

Dehydration of Herring.—In normal times more herrings are caught than can be immediately consumed, and in view of the excellent results obtained in the dehydration of non-fatty fish the Ministry of Food were interested to discover whether any processes could be devised to afford additional outlets for the disposal of the great seasonal harvest of herring which is so great a feature of our coasts. Early in 1944 a pilot plant was set up in Aberdeen to develop the process of dehydration of herring. If herrings, with their high content of protein and fat, could be dried and compressed in the interest of feeding our armies in war time, there was no reason why similar action should not be taken to feed the nation in times of peace. Laboratory work has shown that this can be done.

In the process as actually operated at the pilot plant, fresh herrings, caught overnight, are packed in ice as soon as they are landed and sent to the factory where they are washed, split, gutted and filletted and again washed in special machines capable of dealing with 2 crans of fish per hour. (A cran is a capacity measure, the average equivalent weight of which is 392 lb. or $8\frac{1}{2}$ cwt.) The fish are cooked for 20 minutes under a steam pressure of 6 lb. per sq. inch and then cooled to a temperature not exceeding 45° C. (113° F.). They are then minced and spread on trays to a density of $2\frac{1}{2}$ lb. of mince per sq. foot tray area and passed through the Hardy and Cutting drier.

Under usual working conditions air is delivered to the drying unit at about 30,000 cu. ft. per minute at 79° C. (175° F.). The fat and moisture content of the wet fish vary during the season but average figures are: moisture 64 per cent, fat 14·6 per cent, fat-free solids 21·4 per cent. The minced material is dried down to about 4·5 per cent moisture content; the drying

steam pressure of 2 lb. per sq. inch, the time and pressure of cooking being appropriate to the amount of fish. In cooking whole fish for flaking or larger fillets higher steam pressure is required. Cooking and mincing are essential to obtain uniform particulate material of open structure that can consequently be uniformly and lightly spread on the trays, uniformly and rapidly dried to a product which has good powers of reconstitution and a pleasing, freely fibrous texture when eaten. The juice lost in cooking, about 30 to 40 per cent in lean fish and 20 to 30 per cent by weight in fatty fish, is discarded with negligible loss of flavour and nutriment; there is no need, as in the case of meat, to return the juices to the drying material. After cooking, the minced fish is placed on the drying trays at a density of 2 lb. per sq. foot and exposed in the drying chamber to a temperature which, commencing at 85° C., is gradually lowered during the period of drying to about 65° to 70° C. The wet bulb temperature and the relative humidity fall from initial values of 50° C. and 25 per cent respectively. Under these conditions the temperature of the fish never exceeds 70° C., which is the maximum temperature permitted if a high grade product is to be obtained. The drying time is important; the shorter the drying time the better the quality of the dried product. The practical limit is about 4 hours, the time required to dry from a water content of about 2 7 grams to 0 1 gram per gram of solid. The dried fish contains 4 to 8 per cent moisture, 80 per cent or more of protein and is completely edible compared with the fresh fish which contains 16 per cent of protein and is about 40 per cent edible.

Storage.—Dried fish in a moisture proof container will keep in good condition for about a year at temperatures of 10 to 15° C. By packing in an inert gas, such as nitrogen, the storage life can be extended considerably. Smoked cured products keep somewhat longer than those made from uncured materials.

Dried Fish Blocks.—Dried fish can be pressed into blocks offering maximum economy of space and in this respect de- [illegible] surpasses all other methods of preservation If the [illegible] to 10 per cent water [illegible] obtained by compres- [illegible] of the lean fish. The block is not cohesive and is most conveniently formed in the container. Fatty fish, on the other hand, can be compressed

VEGETABLES

The general principles, already stated, are applicable to the dehydration of vegetables. There are naturally technical differences in the details of the methods used for drying various vegetables. The green leafy and root vegetables require to be thoroughly cleaned, waste leaves or skin removed. Preparation for drying entails shredding, stripping or dicing by machine according to the type of vegetable to be dried.

Green Leafy Vegetables.—Green leafy vegetables are either scalded by steam or immersion, for 2 to 3 minutes, in boiling water containing about 0·22 per cent of sodium sulphite. The sulphite reduces the loss of vitamin C in scalding and prevents discolouration during drying and storage. At the beginning of dehydration, which is carried out in a tunnel (Fig. 47, Group 2, Type 1), the temperature is about 95° C ; towards the end it approaches 60° C. ; the wet bulb temperature is also controlled. During this time, 3 to 5 minutes, the water content falls to 5 per cent. If cabbage, for example, is dried raw, that is without previous scalding, there is a marked loss of vitamin C and considerable discolouration. Steam scalding after dipping the vegetable in sulphite has now been shown to be a satisfactory procedure (Allen, Barker and Mapson 1944). The dried cabbage must be packed in sealed tins so that it will not take up moisture from the atmosphere and, if destined for long periods of storage, it should be packed in nitrogen. The saving of weight by drying is very marked ; 100 lb. of cabbage as purchased gives about 50 lb. prepared for drying and about 8½ lb. of dried cabbage.

Reconstitution of dried cabbage is simple ; the dried material is placed in a minimal amount of boiling water and allowed to cook at 100° C. for 20 minutes.

Potatoes.—Potatoes require very special attention on several points: vitamin C is very readily lost, the high starch content may cause pastiness, and the liability to discolour may be troublesome. The potatoes are peeled, cut into strips about $\frac{3}{16}$ inch by ¼ inch, and washed in running water to remove starch. If not removed from the surface of the strips, starch will cause them to stick together during drying with the production of a rather sticky paste. The loss of starch during washing amounts to about 15 per cent, which in view of the large amount present

ratio (wet fish : dry fish) is about 2·67. When the minced fish has been placed in the drying unit the wet bulb temperature is kept at not less than 50° C. (122° F.) by controlling the inlet and exhaust louvres. The relatively high wet bulb temperature which prevents bacterial growth in the initial stages of drying falls from about 55° to 33° C. (131° F. to 93° F.) during the 4½ hour period taken to complete the process. The drying process having been completed the material is allowed to cool on the trays before being placed in large galvanized storage bins. After 24 hours have elapsed the dehydrated material is mechanically or manually compressed into cans, which are then sealed by soldering.

Deterioration in the flavour of the dried herring, which has a moisture content of 8–6 per cent, may be considerable when the product is exposed to air. This is due to the action of atmospheric oxygen on fat; a better product is obtained by packing under nitrogen. Packed in moisture-proof containers under nitrogen and stored at ordinary temperatures (10°–15° C.) dried fish will keep in good condition for a year.

Dehydrated Kippers.—Kippers are herring which have been gutted and split open down the back by machine, immersed for a short time in salt brine and cured over a smoking wood fire. In the process water evaporates and smoke constituents are absorbed. "Dehydrated kipper" consists of herring fillets smoke cured without brining, and then cooked, minced and dehydrated as for herrings.

The final product of dehydrated cod, haddock, whiting and herring, fresh or cured, has proved acceptable both in terms of taste and texture.

Smoked cod, haddock and whiting have an excellent "finnan haddie" flavour and good texture; flat fish retain their flavour and also the generally crumbly texture of the cooked fresh fish. Smoked dried herrings are said to be better and more acceptable than dried fresh herrings. Dried herring because of its high percentage of fat is particularly liable to deterioration through oxidation; it is therefore essential to pack the dried fish in metallic tins and replace all air with nitrogen. While no final decision has been reached on the optimal water content for storage of dried fish, it may be taken that a water content over 15 per cent on a fat free solid basis would be detrimental on account of the growth of moulds.

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is of no moment. The strips are then scalded for 3 minutes in boiling water containing 0.05 per cent of sodium sulphite or for 2 to 3 minutes in steam after being dipped in a 0.15 per cent solution of sodium sulphite. If the amount of water is as small as possible, the loss of vitamin C will be reduced and there will be a minimal loss of mineral salts by leaching. Vitamin C is also conserved by repeatedly using the same water for scalding. Sulphide and rapid scalding are important if vitamin C losses are to be kept within reasonable bounds. The prevention of darkening of the potato has been a problem, due to lack of knowledge of the chemical processes involved. Acidifying the scalding water and avoiding contact with iron helps considerably but it is best prevented by using a non-darkening strain of potato, of which the King Edward is highly recommended. The temperature and water content are controlled as for cabbage. The dried product should be cooked by adding boiling water to cover it, allowing it to stand for 1 hour and cooking until tender (5 to 10 minutes): this will generally retain 40 to 50 per cent of vitamin C content of the dried potato.

Sealed in cans under nitrogen and stored at 15° C., dried potato will keep for at least a year.

The saving in weight by drying is about 90 per cent; 100 lb. of potatoes prepared by washing, peeling and slicing yield 75 lb. of strips which give a dried weight of 11 lb. Potatoes are a good source of vitamin C: they are also valuable as a source of vitamin B_1 of which 35 to 50 per cent is lost in scalding.

Mashed Potato Powder.—This is a remarkably successful product of the art of dehydration. Potatoes are cooked, mashed and then dried. The dried powder, which is granulated and consists of unbroken potato cells, can be reconstituted immediately by the addition of hot water. The drying is carried out in two stages; first, the wet mash is dried to a consistency which permits of it being ground into a granulated powder in which the potato cells are undamaged; it is then dried on trays in a tunnel. The wet mash may be diluted and spray dried: this gives a very good powder in which no cell damage occurs. By maintaining an undamaged potato or starch cell, no starch

colour; a glazed or shiny surface indicates free starch which will lead to a glutinous product upon cooking. Reconstitution and cooking of the powder is carried out by adding four parts by weight of boiling water to one of riced potato and warming for five minutes. The cooked product resembles mashed potato in flavour, colour and texture. The dried rice powder contains about 60 per cent and the cooked product about 50 per cent of the ascorbic acid in the raw peeled potato.

Mashed potato powder is subject to deterioration—development of a brown colour, charred taste and an off flavour—due to oxidative rancidity of potato fat, storage in the light and increased storage temperatures. To prevent these changes as also the loss of ascorbic acid, the powder should have a moisture content of 8 to 11 per cent and be stored under nitrogen. (Burton 1949.)

Pre-cooked Dried Soups.—Many dried soups are on the market. These consist of hydrolyzed proteins, egg albumin, carbohydrate, fat, vitamins and herbs. The drying is carried out on a roller system. Vitamin C and the flavour, be it meat or vegetable, are well conserved: the essential oils or herbs—mint and thyme oils for vegetable soup and pimento and clove oils for meat and vegetable soup—are added immediately after drying. The powders which are either packed in tins in a neutral gas or in water-proof packages are easily reconstituted by stirring in hot water. The following Table gives the weights of the prepared, cleaned ingredients required to produce one ton of wet purée. (Fidler *et al.* 1945.)

TABLE 72

Vegetable Soup	lb.	*Meat and Vegetable Soup*	lb.
Potato	920	Lean beef	320
Carrot	400	Potato	650
Cabbage	230	Carrot	350
Fat	25¾	Cabbage	192
Oatmeal	44	Fat	55
Salt	17½	Oatmeal	43
Yeast extract	17½	Salt	17
Pepper	¾	Pepper	½
		Yeast extract	13
		Onion	—

Carrots.—Such a rich source of carotene, the precursor of vitamin A, and of carbohydrate, came early into the field of

experimental dehydration. To reduce 100 lb. of raw carrots to 7½ lb. of dried material with but a small loss of carotene was a worth while project. Investigation soon showed that carrots dried without initial scalding, although containing practically all their carotene and sugar, would not keep well and were hard and tough when reconstituted. Scalding the carrots whole, for 15 minutes in boiling water resulted in a dried product which retained 90 per cent of the carotene of the raw vegetable and, with suitable precautions in drying, lost nothing in flavour and texture. For dehydration scalded carrots are cut into strips about a quarter of an inch thick and dried to a water content of 5 per cent in a manner similar to that used for drying cabbage. To reconstitute and cook dried carrot, it is either covered with hot water, left overnight and then simmered in the same water for 20 to 40 minutes, or it is covered with boiling water, kept for an hour and cooked until it is tender. To store dried carrot successfully care must be taken to prevent oxidation of carotene. The small loss of carotene which does occur is not important, because of the large amount present, but oxidations cause "off flavours" which make the reconstituted carrot unpleasant to the palate. It is therefore necessary to pack dried carrot in hermetically sealed tins filled with nitrogen; dried carrots will not store satisfactorily in air; carotene breaks down and in a few weeks a strong smell of violets may develop.

The Drying of Foodstuffs by Vacuum-Oil Technique.—This new method of drying foodstuffs in an edible oil ensures the destruction of enzymes and the retention of flavour and, to a considerable extent, the nutritive value of the foods. The principle of the method is to subject the suitably prepared foodstuff, immersed in a non-aqueous liquid, to a temperature which will destroy enzymes without the removal of a substantial proportion of the water from the food and thereafter to secure the evaporation of the major portion of the water at a low temperature and at a pressure below atmospheric pressure. Before cooking, the oil may be removed from the foodstuff by solvents, draining or centrifuging. It is noteworthy that [illegible] water or water vapour at temperatures about 100° C. [illegible] water soluble vitamins, [illegible] ioned by blanching and scalding. Foods which require to be blanched are kept in oil at 80° C. for 2 to 4 minutes *before* the water is removed. This

treatment destroys enzymes as judged by the absence of oxidase reaction. If the food were dried immediately in oil then a temperature higher than 80° C. would be necessary to destroy enzymes. There is no loss of nutrients into the oily material such as occurs with blanching in water. The flavour and colour of green leafy vegetables, green peas and potatoes are stated to be superior to the flavour and colour of air dried products. The vacuum oil dried products are easily and rapidly reconstituted. The time of drying, the water content and amount of ascorbic acid retained by the vacuum-oil technique are, according to Dr. B. S. Platt (1944), as follows —

Material	Weight grams	Drying time mins.	Water content per cent	Ascorbic acid, percentage retained
Spring greens	100	45	2	70
Brussels sprouts	78	40	4	79
Peas (green)	110	75	7	55
Potato slices	248	60	11	66
Cabbage .	319	90	2	—
Beef raw (minced)	492	130	14	—

FRUIT

Modern fruit drying plant consists usually of forced draught driers. In drying fruit it is usual to recirculate air, maintaining a relative humidity of about 20–30 per cent. An important point in the drying of fruits is that because of their moisture content they are readily "case hardened", that is to say, the surface layer may become hard, due to the rate of evaporation of fluid from the surface being relatively greater than the rate of diffusion of moisture from the interior of the fruit to its surface. This condition is readily brought about when temperatures are too high and relative humidities too low. Generally the more quickly fruit is dried the better the final product. The nature of the material sets a limit to the temperature and humidity that may be employed in dehydration. With an air flow of about 600–800 ft. per min., the fruit being moved against the stream, the temperatures recommended for dehydration of various fruits are as follows: apples, cherries, figs and prunes 160° F.; *apricots and peaches 155° F.*; *pears and loganberries* 150° F.; grapes 180° F. As a result of investigations at the

experimental dehydration. To reduce 100 lb. of raw carrots to 7½ lb. of dried material with but a small loss of carotene was a worth while project. Investigation soon showed that carrots dried without initial scalding, although containing practically all their carotene and sugar, would not keep well and were hard and tough when reconstituted. Scalding the carrots whole, for 15 minutes in boiling water resulted in a dried product which retained 90 per cent of the carotene of the raw vegetable and, with suitable precautions in drying, lost nothing in flavour and texture. For dehydration scalded carrots are cut into strips about a quarter of an inch thick and dried to a water content of 5 per cent in a manner similar to that used for drying cabbage. To reconstitute and cook dried carrot, it is either covered with hot water, left overnight and then simmered in the same water for 20 to 40 minutes, or it is covered with boiling water, kept for an hour and cooked until it is tender. To store dried carrot successfully care must be taken to prevent oxidation of carotene. The small loss of carotene which does occur is not important, because of the large amount present, but oxidations cause "off flavours" which make the reconstituted carrot unpleasant to the palate. It is therefore necessary to pack dried carrot in hermetically sealed tins filled with nitrogen; dried carrots will not store satisfactorily in air; carotene breaks down and in a few weeks a strong smell of violets may develop.

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dehydrated fruit products of good quality have been obtained by sulphuring for the following periods: apples 1 hour, plums, pears, peeled, 1½ hours, plums 2½ hours It has been shown that with heavily sulphured fruit the moisture content should not exceed 30 per cent, in fact it can with advantage be lower, and for fruits of low sugar content 10 per cent is recommended. Fruits generally contain 80–90 per cent of water so that considerable reduction in weight is effected upon drying and the ratio of dried product to the original fresh fruit weight varies according to the nature of the fruit, e.g. for apples it is 6 5 : 1, prunes 3 : 1, apricots and peaches 5 5 : 1, pears 5 : 1. Great differences are also to be found in the time necessary to effect satisfactory drying of various fruits. Apples require 6–10 hours, apricots 10–20 hours, grapes 15–20 hours, pears 10–15 hours, peaches 15–24 hours, prunes 20–30 hours.

Before dried fruits are stored or packed for distribution they are left for some considerable time so that the moisture throughout the batch can become equalized. This process, called "curing" or "sweating", may take several weeks. If dried fruit is to be kept for any length of time (6–9 months) and is to be preserved from darkening processes, it should be thoroughly "sulphured" and stored in airtight containers in the dark at temperatures not exceeding 50° F. (Barger).

THE FUTURE OF DEHYDRATED FOODS

It may be safe to assume that the development of dehydration of foodstuffs will not cause any diminution in the total consumption of fresh foods. Beef produced in this country, fish caught in home waters will still in their fresh state command a market. A great deal of meat is imported and if the cost of its importation is to be reduced it might possibly be dehydrated in the countries where it is produced. Since it is possible to produce dehydrated foods of high quality, there should be no reason to doubt that the future will see a great increase in the use of certain foods. Reference has been made to the saving of shipping space and the dispensing with refrigerated ships by the use of dehydrated meat. The same argument holds for fish caught in distant fishing grounds. Dehydration in Iceland would dispense with the requirement of large refrigerated trawlers which the future needs of the industry apparently

Ditton Laboratory of the Department of Scientific and Industrial Research, it has been shown that good quality products can be obtained from English apples, pears and plums by drying at a temperature of 160° F. with air of 80 per cent relative humidity, the wet bulb depression being 42° F. (180° to 88° C.). The final moisture content of the fruit is 10 to 15 per cent.

In the preparation of fruit for drying it is essential that only ripe fruit of first-class quality should be selected. Prunes, plums, blackberries, raspberries and loganberries are dried whole, cherries are sometimes pitted, apricots and peaches are halved, stoned and the peel removed from the latter fruit. Apples are peeled, cored and cut into rings or some other suitable form such as cubes ; pears are peeled, halved and cored for dehydrator drying ; for sun drying they are only halved.

Fruits that are dried whole, e.g. plums, prunes, grapes and figs, dry very slowly unless the wax covering the surface is removed and the skin rendered more permeable to water vapour. To render the surface skin of the fruit more permeable to moisture the fruit is dipped for a period of 10–15 seconds, depending on the toughness of the skin, in a solution of 1–3 per cent sodium hydroxide at 100° C. ; for tender skinned fruits sodium carbonate solution or plain water suffices. Before being placed on the drying trays the fruit so dipped is rinsed quickly in fresh cold water.

It is well known that injury to the living tissue of many fruits, due to cutting, bruising or the action of heat, results in browning of the tissue due to oxidation reactions catalyzed by enzymes. To prevent such darkening, fruits liable to this reaction are treated with sulphur dioxide which acts as an antioxidant destroying the enzymes responsible for the oxidation processes. The fruit is usually exposed to an atmosphere containing sulphur dioxide produced by passing air through rooms in which sulphur is burning. The fruits which require sulphuring are apples, apricots, pears, peaches and plums, and the temperature of drying is usually about 120° F. The periods of sulphuring are usually short, e.g. apples 15–30 minutes, cherries 10–30 minutes, figs 10–60 minutes, apricots 15–120 minutes, peaches 15–180 minutes, pears peeled, halved and cored 15–180 minutes.

For sun drying, fruits are sulphured for at least 3 hours. Pears require 8–24 hours or more before sun drying. English

dehydrated fruit products of good quality have been obtained by sulphuring for the following periods: apples 1 hour, plums, pears, peeled, 1½ hours, plums 2½ hours. It has been shown that with heavily sulphured fruit the moisture content should not exceed 30 per cent, in fact it can with advantage be lower, and for fruits of low sugar content 10 per cent is recommended. Fruits generally contain 80–90 per cent of water so that considerable reduction in weight is effected upon drying and the ratio of dried product to the original fresh fruit weight varies according to the nature of the fruit, e.g for apples it is 6 5 : 1, prunes 3 : 1, apricots and peaches 5·5 : 1, pears 5 : 1. Great differences are also to be found in the time necessary to effect satisfactory drying of various fruits. Apples require 6–10 hours, apricots 10–20 hours, grapes 15–20 hours, pears 10–15 hours, peaches 15–24 hours, prunes 20–30 hours.

Before dried fruits are stored or packed for distribution they are left for some considerable time so that the moisture throughout the batch can become equalized. This process, called "curing" or "sweating", may take several weeks. If dried fruit is to be kept for any length of time (6–9 months) and is to be preserved from darkening processes, it should be thoroughly "sulphured" and stored in airtight containers in the dark at temperatures not exceeding 50° F. (Barger).

THE FUTURE OF DEHYDRATED FOODS

It may be safe to assume that the development of dehydration of foodstuffs will not cause any diminution in the total consumption of fresh foods. Beef produced in this country, fish caught in home waters will still in their fresh state command a market. A great deal of meat is imported and if the cost of its importation is to be reduced it might possibly be dehydrated in the countries where it is produced Since it is possible to produce dehydrated foods of high quality, there should be no reason to doubt that the future will see a great increase in the use of certain foods. Reference has been made to the saving of shipping space and the dispensing with refrigerated ships by the use of dehydrated meat. The same argument holds for fish caught in distant fishing grounds. Dehydration in Iceland would dispense with the requirement of large refrigerated trawlers which the future needs of the industry apparently

demands. Fish is not at its best when it has been kept on ice while the trawler has spent weeks on the fishing grounds; indeed it is not at its best after 15 days on ice under any conditions. There are still those who regard dehydration as a menace to established industry. As far as fish is concerned "the only menace", to quote the late Sir Joseph Barcroft, "that dessication could present to the trade in home caught fish would be to those dealers who allow it to deteriorate before it reaches the consumer." In other words, fresh food, from *land and sea stands in no danger of a diminishing market.* The public have had experience of dried milk, dried egg powder, dried soup cubes. Many members of the Services have, in addition, eaten reconstituted dried meat and dried vegetables. Dried meat and dried vegetables are unlikely to take the place of preserved meat and vegetables. As long as meats, tongue, pressed beef, etc. and vegetables, e.g. green peas, asparagus, carrots, etc. are preserved in their natural condition in tins or glass vessels, it would seem unlikely that the dried product could successfully compete with them. To attempt to prophesy as to the future of dehydrated foods would be foolish. The future depends upon the improvement of techniques in drying, be it meats, vegetables or fruits. The possibilities of preserving perfect taste, flavour and texture in reconstituted foods are *indeed great.*

There are undoubtedly certain dried foods which should come into general use, and one of these is milk. If for household use *full-cream milk of the highest quality were spray dried* and packed in neutral gas in hermetically sealed containers, it would assuredly be a most valuable food, useful not only for cooking but for the feeding of children. According to Dr. J. A. B. Smith of the Hannah Research Institute: "there is still a great future for the dehydration of milk. Really well made spray-dried milk can be used for almost any purpose for which ordinary liquid milk can be used, and it is to all intents and purposes just as nutritious. There seems to be little doubt that it will always be more economical to produce milk in the summer than in the winter, and provided the general public became aware of the value of dried milk and of the convenience of handling and storing it as compared with handling and storing liquid milk, there may well be a great increase in its use. In that case the so-called 'surplus' summer milk could be dried

and used at other times of the year when liquid milk is scarce." By the use of such a product, all the difficulties which loom so large over the sale of safe milk would be solved.

Dried egg powder has not, up to the present, impressed the housewife. Non-metallic containers, and the lack of storage under nitrogen during the war, have perhaps prevented dried egg powder from being welcomed in domestic circles. Its value in baking, in large catering establishments and for manufacturing purposes is none the less acknowledged, but one cannot expect any artificial product to take the place of a fresh shell egg. The future of the dried egg industry lies in the realm of foreign trade.

future is assured, only the future will tell. As an energy food, it is ideal in many ways for it will reconstitute perfectly even in cold water, and since all the water is taken up by the powder, nothing is lost by leaching out.

In this country fruit has not received the attention it deserves. Dehydration of English fruits should be carried out on a large scale, in order that, irrespective of seasons, fruit may be available in greater measure. Apples, pears, plums, blackberries, loganberries, etc., should form a rich harvest, profitable for both producer and consumer alike. It has been stated that fruit grown in Great Britain, when dried, is of better quality than the imported dried product. According to Dr. Kidd of Cambridge "dried Victoria plums, greengages, etc., after reconstitution and cooking, resemble the fresh fruits".

PRESERVATION OF FOOD

The art of food preservation, which comes down to us from ancient times, arose out of the attempts to postpone or prevent the natural processes of deterioration and decay to which all living matter is subject. Foods change in colour and flavour when damaged or left exposed to the air; the chief factors responsible for such change are enzymes and micro-organisms acting in the presence of moisture and generally, as far as foods are concerned, in the presence of oxygen. The cut apple turns brown; the sprouting grain becomes musty; the germinating pea loses its fresh flavour, and, exposed too long to the air, meat

becomes tainted. On the other hand enzymic action may exert an effect, the appraisal of which is determined by custom or taste; fish which has acquired an odour unbearable to the Occidental may be highly acceptable to the Oriental; a hare hung for a known period of time is received with approbation by some, and eggs have a quality and flavour all their own which, in the opinion of some, ripen with age. The part played by bacteria in decomposing food is already well known; under suitable conditions of temperature and moisture bacteria multiply rapidly, breaking down both protein and carbohydrates. When meat putrifies, toxic amines are formed; these are responsible for the so-called ptomaine poisoning when unsound meat is eaten. One of the most interesting of micro-organisms which causes deterioration of food is the single cell yeast plant. This grows rapidly on food and in virtue of an enzyme produced by, or present in, the cell, sugars are broken down in the absence of oxygen to alcohol and carbonic acid gas; this is alcoholic fermentation, a complex of processes which has been intensively studied by many biochemists.

The various coloured moulds on bread, jam and fruits, with which all are familiar, are made up of small white filaments at the ends of which are small coloured spores—blue, green, brown, etc. Moulds require moisture for their growth, hence the value of a refrigerator or a tightly closed tin box in preventing the growth of moulds on foods. Moulds and yeasts most generally attack fruits, vegetables, bread, cakes, moist cereals and salted meats. Milk and meat are readily attacked by bacteria, while well smoked meat and fish are resistant to yeasts, moulds and bacteria. Enzymes, yeasts and moulds are easily destroyed by a temperature of 65° C. (150° F.), bacteria require temperatures of 70 to 80° C., and spores, which are heat resisting, require higher temperatures and longer heating than bacteria.

Salting, smoking and freezing are probably the oldest known methods of preserving food.

As to when salt was discovered and used as a preservative, there is no record, but, that tribes and armies on land and sailors upon the sea have travelled great distances on food so preserved is well known. Salt has always been used to preserve foods which have a high water content, e.g. meat, fish and vegetables The commonest vegetable preserved with salt is cabbage; the preparation is well known—sauerkraut. Many

fish from many waters are salted and to-day these two foods remain the only representatives of foodstuffs preserved on an extensive scale by means of salt.

Smoking.—Smoking is an ancient method of preserving meat. We can well imagine the experimental method of trial and error, whereby primitive man found that hanging his surplus joint of meat in the smoky recesses of his cave, not only preserved it, but enhanced its flavour. In the more modern methods of smoking meat, advantage is taken of the penetrating qualities and odour of smoke obtained by burning different varieties of wood, for example, in Europe, birch and juniper are used, in America, maple, apple, beech and hickory; and they impart each their own characteristic flavour and taste.

Smoke Curing.—Smoke curing affords a means for the presentation of fish for sale; it also affords short-term preservation by [illegible]
sub [illegible]
hac [illegible]
has lost 15-20 per cent in weight by evaporation. If stored at 60° F. it will remain in good condition and be quite palatable for one week; stored at 32° F. it will remain in first-class condition for 2 to 3 weeks. Heavily salted and heavily cold-smoked products, such as red herrings, keep well for months in temperate climates.

Vinegar.—Another ancient preservative, although not quite as old as salting or smoking, is vinegar. Fermentation of grain was an unexplained mystery to the ancient Egyptians. In more modern times any one who possessed an apple orchard could make vinegar; the addition of a little fermented cider to the newly expressed juice being all that was necessary to convert the sugar in it to acetic acid. Cider vinegar has for long been well known in Europe and America. In the East, vinegar is made from honey and the juices of the palm: in France, or wherever there are good grapes, a fine wine vinegar is obtainable: in this country, malt vinegar is prepared from grain: in continental countries vinegar is made from rye and barley. The sour grapes mentioned in the Bible indicate another source of vinegar. Most foods can be preserved in vinegar and if the vinegar be of good quality it adds to the flavour and palatability of the food. In the past, vinegar was used to preserve fruits but to-day it is mainly used for preserving

cauliflowers, onions, cucumbers, tomatoes and peppers, and as a flavouring agent.

Sugar.—Sugar is an excellent food preservative. To-day it is most commonly used for the preservation of those fruits and foods which, containing a large amount of moisture or juice, can absorb sugar. A 40 to 50 per cent solution of sugar will prevent bacterial action and the growth of moulds. Food, if it has been pre-heated and if the container in which it is placed has been carefully sealed, will keep well in such a solution for long periods.

Eggs.—The preservation of an egg depends upon the reduction, to a minimum, of its metabolic activities. The living egg slowly dies, not as a result of bacteria gaining entrance through the shell, but as a natural process of ageing. This process can be delayed by preventing the loss, through the shell, of the CO_2 produced in the egg. The U.S. Department of Agriculture have carried out experiments where the air has been sucked out through the " pores " of the shell and oil allowed to enter: the egg is thus effectively sealed. For the preservation of eggs in bulk the method is good; for domestic, short time preservation a varnish, such as " Oteg " is very good.

Preservation by Freezing

The storage of food in ice cold boxes or rooms is a simple procedure. In winter by means of saws, picks and hoisting gear large blocks of ice are cut from the frozen rivers and lakes. These blocks are floated ashore and stored in ice houses which, in the United States of America and Canada, are built of wood and have double walls. The principle of cold storage by means of ice is to secure a circulation of cold air: the warmer air at ground level is cooled as it rises and when sufficiently cooled falls again to the ground. Storage ice is sold in American cities and towns, the housewife thus securing, daily if necessary, ice for her ice chest. From this simple but practical method evolved the present day refrigeration plant, which commercially can freeze foodstuffs very quickly at temperatures as low as $-50°$ F.

Cool Storage.—The effect of " cool storage " or chilling, as in the presence of ice where the temperature is above freezing point, is to reduce considerably the rate at which chemical

changes in food proceed. These changes are associated with respiration, ripening and ageing of fruit, the growth of yeasts, moulds and bacteria and, in non-living foods, autolytic and enzymic action. For meat the usual storage temperature is [illegible]

packed in crushed ice. Since white fish can remain reasonably fresh for no longer than about 12 days under such conditions, and as temperatures in the holds of vessels are variable, the method, unless improved upon, affords few advantages to-day. Herring, which are usually caught overnight, remain stable for about 12 to 18 hours at a temperature of 55° F. If packed in ice they will remain in good condition for about 2 to 4 days. Eggs stored at a temperature of 30° to 32° F. and at a relative humidity of 85 per cent will show little signs of bacterial spoilage at the end of a month. For transportation from New Zealand and Australia butter must be held at frozen storage temperatures, i.e. 10° to 15° F. Cheese, which would crumble after such exposure, is transported over long distances at a temperature of 45° F. Fruits and vegetables vary greatly with regard to the time of cool storage at 30° to 34° F.; soft fruits — strawberries, blackcurrants, raspberries—and green vegetables retain their qualities of freshness, taste and appearance for 10 to 14 days; the firmer fruits—plums, peaches, grapes, 3 to 8 weeks; citrus fruits store well if picked when sweet enough to be eaten, oranges at 45° F. and grapefruit and lemons at 50° to 55° F. Certain fruits are subject to low temperature injury and attention must be paid to their degree of ripeness when picked and their rate of ripening while stored; apples (Bramley's Seedling) suffer softening and discolouration if exposed to temperatures below 36° F.; bananas must not be stored at temperatures below 54° F.; ripe plums are safe for weeks at 34° F., while unripe plums fail to develop their normal juicy character after removal from storage at 34° F. (Morris, 1950).

Frozen Storage.—The advantage of rapid freezing—41° to 23° F. in 30 minutes—is that the water within the cells is deposited as very fine crystals which do not break the cell wall. In slow freezing large crystals are formed which, by breaking the cell wall, results in a loss of juice from the food upon thawing, the foodstuff also losing some of its appearance and flavour.

Meat and Fish. For the transport and storage of frozen meat, butter and fruit for jam-making the temperature has for many years been 14° F.; for fruit and vegetables and also fish 0°–10° F. is necessary if the highest quality is to be retained over periods of 6 or more months. White fish stored frozen can remain virtually without change for 4 months at – 5° F. and for 8 months at – 20° F. From the condition of the fish as generally landed it is clear that freezing on shore cannot provide a high grade product on a large scale. The only way to supply really fresh white fish all the time is to freeze it at sea. Quick-frozen herring have been found to keep in very good condition for 6 months if frozen at a temperature of – 16° to – 18° F. and stored at – 17° F. If frozen at – 16° to – 18° F. but stored at 0° F. they will only keep in good condition for about 3 months.

Fruit. Certain fruits and vegetables undergo changes even when frozen fresh at 0° F.; these changes are responsible for unpleasant flavours, loss of colour and alteration in the structure of the food which causes juice to be lost and the food to become soft.

Freezing in syrup or sugar is effective in preventing browning during storage provided the fruit or vegetable is completely immersed in the syrup. Raspberries, gooseberries, blackberries, redcurrants and bilberries can be successfully preserved by freezing in syrup. Plums and cherries, while equally well preserved, tend to discolour during thawing, even when kept under syrup until room temperature has been reached.

With fruit, scalding and freezing in syrup does not appear to be in any measure more advantageous as regards the retention of nutritive qualities and flavour than canning. Fruit must naturally be frozen quickly enough to prevent deterioration by enzyme action.

In the preservation of fruits to-day, they are usually frozen in the fresh condition under syrup, or mixed with sugar. The usual method is to subject the fruit to sharp freezing at low temperatures (– 30° to – 40° F. are used in United States of America), and to store at about 0° F. to – 10° F. Fruits *cooked* in syrup or water can be stored in the frozen state for special purposes, if desired, at moderately low temperatures—14° F. (– 10° C.). If fruit is to be cooked subsequently, storage in syrup at a temperature of 10° to 15° F. is sufficient. Many

fruits discolour readily and if they are to be stored for long periods the temperature must not be above 10° F. If fruits have been scalded, then storage at 15° F is quite satisfactory. The lower the temperature, the better the product; strawberries and raspberries stored at 0° F. are always better in colour and flavour than those stored at 15° F. Quick freezing of fruits and vegetables at temperatures of − 40° to − 50° F. always results in a firmer texture and better appearance as, for example, with certain varieties of strawberry and with asparagus. Reasonably rapid freezing of small quantities of material at − 40° to −50° F. and storage at 0° to − 10° F are used in the comparatively new frozen pack industry.

Vegetables.—Scalding or bleaching is necessary to avoid slow enzymic or oxidative changes which go on in raw vegetables even at low temperatures and during thawing Scalding, before freezing in syrup, has given good results with peas and runner beans, these two vegetables being more readily damaged than most by the high temperature required for sterilisation In the new frozen-pack method, vegetables are frozen quickly at − 30° to − 40° F. and stored at 0° to − 10° F. If the foodstuffs have been previously scalded, vegetables, like peas, runner beans, etc, can be held in storage for periods of a year or more with little deterioration or loss of vitamin C. Very quick freezing, such as would be obtained by immersion in a liquid refrigerant such as cold brine, is necessary for frozen-pack asparagus if it is not to be limp and soggy after cooking.

The rate of thawing has been stated to exercise some effect upon the quality of frozen fruits. Work at the Low Temperature Research Station, Cambridge, has not shown that slow thawing over a period of 24 hours at 34° to 40° F is more advantageous than a more rapid thawing at higher temperatures.

Herring.—At least two methods are available for preparing "quick-frozen" herring. In the "multiplate" freezer, the herrings made up in packages, typically weighing half a stone, are frozen in tray moulds between plates through which liquid ammonia or other refrigerant passes, the evaporation temperature being usually about − 25° to − 30° F.

In the other method,the air-blast "process", the herrings packed similarly in half-stone lots but without wrapping in tray moulds, are frozen in a rapid current of very cold air (about − 30° F.). Semi-continuous counter current or cross

flow freezing tunnels are normally employed. On emerging from the tunnel the frozen fish are removed from the trays by spraying the under surface with water at normal atmospheric temperature. The blocks of fish are then sprayed with or dipped in fresh cold water (40° F.) two or three times with intervening subjection to a cold air blast for very short periods. This "glazes" the fish with a skin of ice which prevents oxidation of the fat and desiccation through evaporation of moisture in cold storage.

In both processes the blocks are completely frozen within two hours. Quick frozen herrings should be stored at − 20° F. when they will keep in excellent condition for about six months. Kippers can also be successfully quick frozen.

With the assistance of the Torry Research Station (Aberdeen) of the Department of Scientific and Industrial Research, at which the principles of good practice in freezing herrings had been worked out, the Ministry of Food in 1941 successfully ran pilot scale plants using both methods. Since then the Herring Industry Board and commercial enterprise have developed these processes on the full scale with the ultimate aim of providing the public with herrings and kippers all the year round.

Development is slow. Low temperature storage facilities are still very limited. The present frozen pack is still too expensive in labour and in packaging materials. Research is in progress with a view to mechanization on the basis of larger "glazed" unit blocks of fish. (G. A. Reay, 1951).

The Frozen Pack.—For direct consumption this method of storing raw or scalded fruit and vegetables is of interest. Fruit *of the very best quality is filled into containers—tin, carton* or glass—covered with syrup of 50 per cent strength and frozen quickly. Fruits like raspberries and currants, which do not turn brown or lose flavour, may be frozen without syrup, but freezing in syrup is to be preferred if fresh flavours are to be retained to the greatest degree possible: vegetables, such as peas, runner beans and asparagus lend themselves to this method of freezing. Peas, prepared by scalding in boiling water for not [illegible] water and [illegible] l is added, [illegible] nsumption.

If no liquid is used, precautions must be taken to prevent

evaporation during storage. No alkali is used and only first-class young and fresh peas are selected. Peas in the pod are practically sterile: shelled, they are open to bacterial infection which will cause discolouration; they must therefore be prepared and frozen quickly.

In November 1945 the Ministry of Food decided to grant facilities for re-establishing the quick freezing of fruits and vegetables, among the varieties to be marketed being strawberries, raspberries, gooseberries, currants, asparagus, green peas, runner beans and broad beans.

Canning of Fruits and Vegetables

The first step in the canning of vegetables is to select material of the highest quality; then to wash, cut into convenient sizes and scald or blanch. In dehydration, the loss of vitamin C was minimized by serial scalding and by the use of sodium sulphite in the scalding water. In canning vegetables this is not done, because sulphite is a great accelerator of corrosion, especially with acid products. The material is filled into the can, covered with water and the can closed with the exception of the outlet for heat exhaustion. Air is largely excluded [illegible]

hot. There is therefore little possibility of losing any vitamin C by oxidation. Canned vegetables contain as much vitamin C and soluble nutrients as similar amounts of vegetables cooked in the home (Olliver, 1941).

In canning fruits it is not usual to scald or blanch them, the only exceptions being apple-slices and pears. After careful selection and necessary preparation, the fruit is placed in the can. The slight acidity due to organic acids helps to protect the vitamin C, even in the presence of oxygen. Oxygen, however, is driven out of the cans, as far as possible by correct filling and heat exhausting. This minimizes corrosion, as tin is not attacked by organic acids in the absence of air. Canned fruits should always be kept in a cool place where the temperature is as near the freezing point as possible.

Storage for Canning. Strawberries, raspberries, peas and runner beans for canning out of season are frozen in syrup of canning strength, i.e. 50 to 55 per cent of sugar, using the same

proportions of syrup and fruit as in canning. The syrup and fruit are quickly frozen to − 10° F. and stored at 0° to 10° F. Another method is to heat the fruit to 176° F. for 3 to 4 minutes in syrup (50 per cent), cool as rapidly as possible, freeze and store at 14° F. The pre-heating ensures that no deterioration in flavour will occur during storage. It is maintained that these fruits and vegetables are, when served, indistinguishable from those canned fresh. (Morris and Barker, 1937.)

The Canning Industry. Canning is essentially an American industry. It had its origin in France, when, as a result of food shortage during the Napoleonic Wars, the government became interested in an invention by Nicholas Appert for the preservation of food. Using glass bottles with cork stoppers, Appert cooked various foods, bottled them, recooked them by boiling the bottles in large kettles and set them aside for varying periods. As a Frenchman and a chef, Appert made up meals of such delicacies as only a Frenchman could—" eels, carp and pike garnished with veal, sweetbreads, mushrooms and anchovy butter cooked in white wine "—and subjected them to the test of preservation by boiling. His methods were good, his glass containers were not so good. An Englishman, Duran by name, produced the tin can with the required hole in the top which, after boiling, was closed by soldering. In 1817, William Underwood went from England to New Orleans to open a canning business, but failing in New Orleans to get sufficient financial support, he proceeded to Boston and there founded the first food preserving firm in America. Ere long almost every known foodstuff was experimentally canned. In the course of time, some thirty to fifty years, the canning of salmon, oysters, sardines, meat, fruits and vegetables had become an established and profitable industry. The path of progress was certainly [illegible] in

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preservation of food was a great step forward, and by 1900 several bacteriologists were employed by the industry in U.S.A. Engineering skill led to the development of machinery for the making of tins, the lining of metal cans with tin, the sealing of heat exhausted cans and also for gathering and preparing the foods which were to be preserved. Every foodstuff destined for the canning industry is now specially grown; factories are

established in close proximity to centres where the foodstuffs are produced. From the field to the can, the foodstuff is, in many cases, never touched by hand. Peas are gathered and shelled; fish are cleaned and suitably cut; pineapples are peeled and cut to required size; and even the photo-electric cell keeps an invisible eye upon some of these processes lest anything but the best be passed for sterilisation by bleaching, scalding or final heating. To-day some of the freshest and the finest foods are in cans. The idea that inferior foods are the stock in trade of the canning industry is quite wrong. Research has shown that canned vegetables and fruits contain as much vitamin C as the fresh food. Indeed one need only examine Brussels sprouts, cabbages, cauliflowers, etc., as they lie broken and bruised in the average greengrocer's shop to realize that the destruction of vitamin C and other nutrients in such food has proceeded apace in certain parts of the vegetable, much of which has to be discarded before it is ready for cooking.

The tin can is still open to some suspicion, since it may not be entirely tinned and food may come into contact with the iron of the can. This is of little moment, particularly in cans filled with nitrogen. In cases where tin may cause discolouration of the contained food the can is enamelled. Many people are still of the opinion that preservatives, boric acid, benzoic acid, formaldehyde or salicylic acid are used as preservatives. These chemicals did protect from spoilage but to-day they are seldom [illegible]

preservatives. As has been shown, oxygen is the agent which must be removed if food is to be well preserved. Tin itself plays the part of a protective agent in that it tends to absorb any residual oxygen in the can.

Foodstuffs, be they dried or preserved, should be made available to all. Scientific research has made possible a great variety of palatable and nutritious foods, both in the dried and preserved state. To the housewife in her kitchen these foods in their fresh state represent long periods of tedious preparation, if not unqualified drudgery. There is no reason why the housewife should not benefit by scientific achievement. By making full use of mechanical methods for the preparation of vegetables, not only is time and labour saved, but there is made possible

a better and fuller use of valuable foods. The cost of such prepared foods will be greater than that of the raw products, but the advantages, namely, less labour, reduced cooking costs and greater variety, will far outweigh the increased expenditure.

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CHAPTER XIX

DIET AND DENTAL CARIES

One of the most outstanding defects of the people of this country, taken as a whole, is dental caries. It is one of the strongest links in the chain of events which produces malnutrition, for a deficient diet leads to bad teeth and bad teeth lead to bad digestion and assimilation of any diet. The question of the development and preservation of good teeth is one of vital importance to the nation. The cause of tooth decay has been the subject of much discussion and controversy and as yet there is no unanimity of opinion concerning it. Many questions concerning the ætiology present themselves to us. Is it due to bacteria, to fermentation in the mouth, or to a faulty diet?

To understand the rôle of the various factors upon which the development of teeth depends, a knowledge of the structure of the teeth is necessary. The external surface of a tooth is hard enamel, composed of phosphate and carbonate of lime. Its formation is brought about by the calcification of a substance secreted from the cells (ameloblasts) of the "enamel organ". Beneath this is a dense, bone-like substance, dentine, which forms the main part of the tooth. The dentine is made up of numerous fine tubules which radiate outwards and upwards from the pulp cavity. The tubules contain elongated processes which have their origin in odontoblasts or the superficial cells of the pulp. When the dentine is injured, these cells are stimulated to fresh activity, and form new or secondary dentine. Stretching downwards from the part where the hard enamel comes into contact with the gum and lying between the dentine and the bone is a thin layer of cement. Between the cement and the mandibular bone there is a layer of tissue called the periodontal membrane or dental periosteum. The pulp contains blood vessels, nerves and odontoblasts or dentinal cells. The relation of these various parts one to the other is shown in Fig. 48: it is upon the vitality of all these dental tissues that the soundness of the teeth depends.

It has been shown that diet plays an important part in the

development of the body and it can be shown that it plays an equally important part in the growth of the teeth, a part which is ante-natal as well as post-natal.

The Development of the Teeth.—The germ of the incisors of the *deciduous dentition*—the milk teeth—first appears in the fourteenth week of embryonic life; *calcification* begins about the twentieth week and is completed between the eighteenth and twenty-second months after birth. While the first signs of *calcification* of the *permanent teeth* are evident about the time of birth, the first appearance of the "germ" or nucleus of development of these teeth is seen at the twenty-fourth week of intra-uterine life. Between the first and the fifth year *calcification* of the *permanent* teeth begins and is completed between the eleventh and eighteenth year, with, of course, the exception of the third molars.

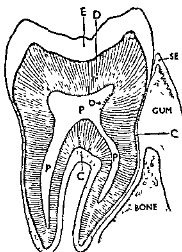


Fig 48.—Longitudinal section of a molar tooth of a man showing the three main elements of the tooth, dentine, enamel and cement and the relation of the periodontal membrane to cement (Partly re-drawn from Sobotta)

E = Enamel.
D = Dentine
P = Pulp
C = Cement.
SE = Sublingual epithelium
O = Position of odontoblasts

The deciduous dentition begins to erupt between the sixth and eighth month, with the appearance of the central incisors and should be complete by the end of the second year. There are wide variations in time and considerable irregularity in the order of appearance of the teeth. The

th the eruption of
year followed by
bicuspids, canines

and second molars erupt between the ninth and fourteenth year followed by the third molars two to six or more years later. Therefore, throughout a period extending from the fifth month

of intra-uterine life to the years of adolescence, the structure of the teeth is exposed to the influence of nutritional factors.

The Fat Soluble Vitamins A and D and the Mineral Salts.—A survey of the literature on the relation of dental caries to vitamin and mineral dietary deficiencies shows definitely that dental caries is the result of many factors. Of these the best known are vitamins A and D and the salts of calcium and phosphorus. With knowledge limited to such a small number of factors, it must be admitted that dental health can best be conserved by a good diet rather than by specific vitamin or mineral therapy. It would appear from the researches of Lady Mellanby in this country, Professor Wolbach and his colleagues of Harvard University and many others, that the activities of the nutrients referred to are specifically related to the structural elements of the teeth. That vitamin A has a definite action in maintaining the growth of the incisor teeth in rats and guineapigs is shown by the chalky or white appearance and brittle nature of the enamel of these teeth when the animals are fed on a vitamin A deficient diet. Upon the withdrawal of vitamin A from the diet, the enamel organ soon ceases to function and, with the subsequent loss of enamel, dentine is exposed; ultimately the odontoblasts suffer damage and finally atrophy.

In caries, experimentally produced by feeding animals vitamin A and D deficient diets, or by giving a diet low in calcium and lacking *vitamin D, it has been noted that caries was frequently* associated with the development of rickets. Is is known that children will develop both caries and rickets even when their diet includes milk, and therefore is not lacking in calcium, but is almost free from vitamin D. Puppies fed on a rickets producing diet, that is a diet deficient in mineral salts and vitamin D, show thickened jaw bones, delayed eruption and irregular formation of the teeth, with a rough and grooved enamel and a poorly formed dentine. Fig. 49 from Lady Mellanby's researches on the effect of diet on the teeth, show the result of a vitamin D deficient diet as also the remarkably beneficial effect of adding fat soluble vitamins A and D. The effect of alterations in the fat soluble vitamin content of the



FIG 40 —A The influence of vitamin A and D on development on the periodontal tissues Diet from 1½ months for 6½ years contained bread and a liberal supply

normal

months

B1 At

years,

much absorption of alveolar bone and irregul ir calcification [*From Lady Mellanby's "Diet and the Teeth, an Experimental Study", M R C, Special Report By kind permission of the Controller, H M Stationery Office*]

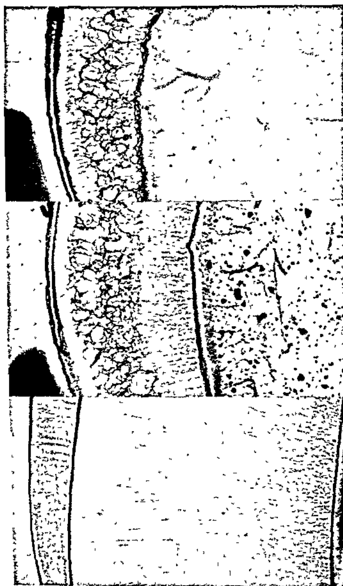


Fig 50

FIG 51.—The effects of salts of calcium and phosphates with varying quantities of vitamin D on the lower jaw and teeth Puppies 6 weeks old, duration of experiment about 23 weeks. No. 1 Sodium acid phosphate 0 5–0 74 g, olive oil 10 c c. Last month [illegible]

very rough and very pigmented. No 4. Calcium carbonate 0 37–0 74 g, olive oil 10 c c Enamel fairly thick but badly calcified, rough and pigmented. Calcification shows improvement. Dentine and cement better than in the previous cases No 5 No extra salt. Cod liver oil 10 c.c. Note smooth white glistening enamel which is thick and well calcified The dentine and cement are normal as is also the bone. [*From Lady Mellanby's "Diet and the Teeth, an Experimental Study", M R C., Special Report By kind permission of the Controller, H. M Stationery Office*]

[To face Fig 51.



1



2



3



4



5

FIG. 51.

three photomicrographs in Fig. 50 are of the lower carnassial teeth of three puppies of the same family, which, at the age of six weeks, were all given, as a basal diet, oatmeal 40–100 grams, separated milk powder 20–30 grams, lean meat 10–20 grams, orange juice 3–5 c.c., yeast 3–5 grams and sodium chloride 1–4 grams. The puppy, the section of whose teeth is shown in No. 1 of the figure, was given 10 c.c. of olive oil throughout the whole experiment; the calcification of the dentine was poor; the percentage of calcium oxide in the teeth was 15·3 g. In No 2, cod-liver oil was given during the last month of the experiment and the section shows poor calcification in the earlier part of the experiment and a marked improvement in the formation of enamel and dentine during the last month. The older dentine is globular, while the newer dentine close to the pulp has much smaller globular spaces, and the amount of dentine formed in one month equals that of the previous four months; the calcium had increased, the percentage of calcium oxide being 20 4 g. The value of cod-liver oil in maintaining good development of the teeth is shown in No. 3 where a large amount of well calcified dentine has been produced in the same time as the small amount of badly calcified dentine in No. 1. The marked improvement is reflected in the amount of calcium oxide in the teeth, namely 29·4 g. per cent. The effect upon the teeth of the deficient dietary over a prescribed period is permanent. This demonstrates how possible it is, by examining a section of a tooth, to determine its dietetic history in terms of calcification. In Fig. 51 are shown the effect of salts of calcium and phosphorus added to a basal diet similar to that given in the previous experiment. The amount of calcium added to the diet of the puppies, the photographs of whose teeth are shown in Fig. 51, Nos. 2 and 4, was approximately equal to that in 125 to 250 c.c. of cow's milk, the total calcium content of the diets being equivalent to that in 370 to 550 c.c. of cow's milk (i.e ⅔ to 1 pint of milk). The phosphorus added was equivalent to that in 80 to 160 c.c. of milk. Taking the maximal amounts of the foods in the basal diet we find that the diet contained 10 7 grams of protein from dried skim milk powder, 3 5 grams from lean meat and 12·1 grams from oatmeal, making a total of 26 3 grams of protein of which 14 2 grams are animal protein. The calcium intake was 55 mg. from oatmeal and 367 mg. from dried milk powder (= 10 5 oz. of milk),

of vitamin D in the control of dental caries in children, McBeath and Zucker of Columbia University, U.S.A., examining over 800 children, 6 to 14 years of age, for a period of four years, found the greatest number of
late winter and early spring,
Given graded amounts of vit
they were able, by the use of the highest dose of vitamin, to prevent the appearance of any increase in the number of new cases of caries in the late winter and early spring months. There is evidence also to show that sunshine and warmer climatic and living conditions are not without their effect in the prevention of dental caries.

Vitamin C.—Vitamin C, the anti-scorbutic vitamin, has also a specific function in the development of healthy teeth. The bleeding gums and progressive loosening of the teeth in scurvy are evidence of the lack of ascorbic acid in the diet. That under these conditions changes are present in the structure of the teeth was first recorded in 1916 by Jackson and Moore who described hæmorrhages in the pulp of the teeth of guinea-pigs. In 1919 Zilva and Wells corroborated this and further showed that the first signs of scurvy in monkeys were to be found in the teeth. These signs related to changes in the microscopic appearance of the odontoblasts from which the dentinal tubules develop and upon whose normal tubular structure the nutrition of the teeth depends (Bodecker, Hojer). Continued deterioration of the teeth results in damage to, or destruction of, the enamel forming cells (ameloblasts) (Fish and Harris, 1934) Vitamin C also controls the formation of the cement layer between the gum and the dentine, so important for the firm setting of the tooth in the bone.

It will be noted that these important findings had, in the first place, their factual bases in experiments on rats, dogs, guinea-pigs and monkeys. They establish the fact that it is during the period of growth and development of the teeth that the vitamins play their most important rôle, that is, from the time of laying down the germ of the deciduous incisors to the full development of the permanent molars; there is no claim that vitamins therapeutically employed can cure an established condition of dental caries.

Fluorine in Dental Nutrition.—In 1930 Kempf and McKay described opaque white mottling with brown staining

a total of 422 mg. The protein and calcium are ample for the growth of the type of puppies used in these experiments. There is, however, an *entire absence of the fat soluble vitamins A* and D. The addition of calcium carbonate to the basal diet but imperfectly improved the teeth; the addition of vitamin D had a dramatic effect. These experiments also showed that increasing the amount of cereals would produce rickets in young animals whose diet was deficient in vitamin D. It was explained at that time that cereals increased the rate of growth of animals but did not at the same time supply the necessary elements to ensure the perfect formation of the bones and teeth. While the degree of calcification of bones and teeth depends upon the relative proportion of calcium and phosphorus, protein and vitamin D in the diet, it has been shown that the cereals which contain the larger amounts of calcium and phosphorus, such as oatmeal, maize and wheat germ, caused the lowest retention of the minerals in the bones and teeth. This led Harrison and Mellanby to search for a rachitogenic or rickets producing factor. In 1939 they stated that the constituent of the cereal producing this effect was phytic acid (inositol-hexaphosphoric acid), and it did so by interfering with the absorption of calcium, present either in the cereal itself or in other foods. While phytic acid is present in cereals and, although of all cereals examined oatmeal appears to have the highest content of phytic acid (0 225 %), it must be stated that, from the point of view of practical nutrition, there is no reason to believe that the phytic acid in cereals exerts any rachitogenic effect in good diets. The phytic acid acts by binding a certain amount of calcium; this can be offset by increasing the calcium intake, for example, by drinking more milk, or eating more vegetables. When milk is taken with porridge, one-third of a pint to 1 oz. of oatmeal as porridge, there is more than a sufficiency of available calcium to saturate the phytic acid. The rachitogenic action of cereals is only likely to become operative in diets which are *on, or below, the border-line of minimum requirements* of calcium and vitamin D, and unfortunately it is in [illegible] border-line diets that cereals are disproportionately high

[illegible]

of a seasonal incidence of dental caries. In a study of the role

sufficient to cause definite mottling of the enamel. According to Professor Murray of Bedford College, London, few waters in England contain more than 1 p.p m.; the fluorine content of the river Thames is 0·10 p p.m., the drinking water in Launton, Oxfordshire, contains 0 85 p.p.m., in Maldon, Essex, it is 5 0 p.p.m, this town being noted for mottled teeth.

Diet and Parodontal Disease.—Parodontal disease is a term which describes the various pathological changes in the supporting structures of the teeth. It is used to cover all departures from health of the gum, periodontal membrane, cementum and alveolar bone and of the nervous, vascular and other constituents of which these tissues are composed. Parodontal disease in man has been the field of many investigations which have resulted in much controversy but little in the way of elucidation of its cause. The various nutritional factors in the diet have been investigated; vitamins A and D seem to have little or no effect upon it, nicotinic acid in large doses has been proclaimed on the one hand as a cure (Platt, 1939) and on the other of no avail in alleviating the symptoms (Coulson, Ellinger and Smart, 1945). There is no doubt that in the hands of some, administration of nicotinic acid in doses of 150 mg. daily with local hygienic therapy with or without gentian violet or chromic acid has resulted in the disappearance of the disease (King, 1943). Several conflicting reports have been made on the efficiency of vitamin B_2 in combating the disease. Vitamin C has many advocates. Difficulties naturally arise in differentiating between the healing effect of vitamin C and any effect it may have in combating gingivitis. The occurrence of gum lesions in experimental scurvy has been demonstrated by Crandon who placed himself on a vitamin C deficient diet for 6 [illegible] the teeth [illegible] copic gin- [illegible] disease in vitamin C deficiency has been corroborated by others. Certain investigators have suggested that the conflicting evidence on vitamin C in relation to gingivitis can be explained by assuming [illegible]

A good deal has been written on the effect of hard and soft foodstuffs on the health of the gums. The retention of

of the teeth in the inhabitants of a small town, Bauxite, in Arkansas, U.S.A., where all drinking water, at that time, came from deep wells. The inhabitants of the neighbouring town of Benton, who drank river water, showed no mottling of their teeth. A chemical analysis of the water in 1930 gave no hint or clue as to the cause of the disfigurement. In 1931 Smith, Lantz and Smith of Arizona University were the first to show that fluorine was the cause of mottling of the teeth. Fluorine, which occurs as a trace element in certain drinking waters, is found in rock phosphates, cryolite, a double fluoride of sodium aluminium and in fluorspar which is used as a flux in glass etching. It is regarded as the cause of the mottling of the enamel of the teeth, characterized by opaque bands and, in some cases, brown staining. Mottled teeth may be structurally good or bad. It has generally been considered that mottled teeth are resistant to caries (Black and McKay, 1916). In America, Armstrong and Brekhus (1938) found more fluorine in sound teeth (0·011 %) than in carious teeth (0·006 %). In Tristan da Cunha, where the inhabitants show "threshold" mottling of the teeth and are often referred to as excellent examples of non-carious teeth, the fluorine content of the drinking water is 0·2 parts per million (Sognnaes and Armstrong). The detrimental action of fluorine takes place during the development of the teeth, the permanent teeth being more affected than the temporary ones. In industry fluorine poisoning of adults affects, not the teeth, but the bones, causing osteosclerosis of the vertebræ, pelvis and ribs. In India, Col. H. Shortt, I.M.S., F.R.S., and his colleagues have described cases of fluorine poisoning in which, at about 30 years of age, pain in the limbs, ossification of periarticular tissues and stiffness of the spine were characteristic. The amount of fluorine in the drinking water was 3 to 4 p.p.m. In this country no such skeletal changes have been found associated with mottling of the teeth. It seems that low concentrations of fluorine favour calcification but that concentrations of fluorine over M/10,000 is detrimental to the calcification of bones and teeth. Recent work by Kemp, Murray and Wilson (1942) has shown a relationship between dental fluorosis and slight changes in the end plates of the bodies of the vertebræ in children. In U.S.A. it is considered advisable to change the drinking water when the fluorine content exceeds 1 p.p.m.; 1·6 to 3 p.p.m. being regarded as

before birth and complete their calcification between the ninth and tenth years · they erupt generally during the sixth year and are known as "the six year molars". Upon eruption they have 3 to 4 years of further calcification before them. It has been said in U S.A. that only about 60 per cent of children can, before their eighth birthday, display four perfectly sound first molars.

That nutritional factors have played a part in the general improvement of the teeth and of their resistance to disease is fully accepted. Confirmation of a steady, if slow, decrease in the incidence of dental caries is given in a recent publication by Lady Mellanby and Dr. Helen Coumoulos, on the improved dentition of 5-year-old London County Council school children in which the results of dental surveys carried out in 1929 and 1943 are compared. In considering reasons for this improvement it should be remembered that for the past 25 years the Government has, through ante-natal clinics and child welfare centres, made special efforts to improve the standard of nutrition of pregnant women, nursing mothers and children. In 1934 the Milk in Schools Scheme came into operation whereby children could receive one-third of a pint of milk every school day. During the war priority schemes permitted nursing mothers, infants and young children to receive cheap milk, orange juice, cod-liver oil and eggs. These priorities, with the better distribution of essential foods, have had a beneficial effect upon the general nutrition of children. This is amply borne out by surveys of the clinical condition of the children in schools throughout the country and by the dental surveys of 1929 and 1943 In these dental surveys two points have been noted, (a) the structure of the teeth, and (b) the incidence of caries. In the former, imperfections of surface structure were classified into four categories : normal, where the surface is smooth and shiny ; slightly defective ; defective and very defective ; in the latter there were also four categories, namely, no caries, slight caries, moderate caries and advanced caries. Table 73 shows the changes which have taken place. These figures show a definite improvement in London County Council Schools over a period of 14 years ; 19 per cent of the children had perfect or nearly perfect tooth structure in 1943 as compared with 8 per cent in 1929 ; and 33 per cent had very defective structure of the teeth in 1943 as compared with 58 per

food particles between the teeth has in many quarters been regarded as the main causative factor leading to dental decay and infection of the gum by bacteria, and the prevention of such was supposed to be due to the cleansing action of hard foods which prevented the deposition of tartar. Experiments on animals (the ferret) have shown that the gnawing of sugar cane for a period of 8 weeks resulted in a rapid improvement in soft, hæmorrhagic gums, due to the removal of the dental calculus or tartar. It was noted, however, that calculus deposits if relatively slight and soft recovered fairly rapidly by this method of sugar cane therapy; in the presence of heavy accretions of hard tartar little but temporary stoppage of hæmorrhage of the gums could be effected. It was noted, however, that in all these cases the recovery was limited to the labial surface of the gum in the region of the incisors and canines only. Little curative effect was visible at the posterior part of the gums, which indicated that areas inaccessible to friction by the cane showed no improvement.

In man chewing sugar cane has similar prophylactive and curative effects, but only in those areas of the denture accessible to the cane, provided that the tartar round the necks of the teeth is not too heavy and that additional systemic complications are not present (King).

Dental Surveys.—The studies of Lady Mellanby, in this country, on the relation of the surface structure of the teeth to dental caries showed that in 1500 sectioned deciduous teeth there was no caries in 78 per cent of teeth with well calcified dentine and enamel and extensive caries in only 7·5 per cent of teeth of good structure. She also found that deciduous incisors are as a rule better calcified than deciduous molars due to the fact that incisors are almost completely calcified before birth. Incisors are less liable to decay than molars. An examination of permanent teeth in children, 6 to 14 years of age, showed "the prevalence and degree of caries to be comparatively small in such young children since the majority of the permanent teeth have only recently erupted or are erupting. Nevertheless, the percentage of diseased teeth is seen to increase with the severity of surface defects."

One of the most revealing findings in any dental survey is the percentage of children of 7 years of age who have a decayed first molar. The first molars begin to calcify just

reverted to that of 1943. The dental structure, while not quite as good as in 1947, was still definitely better than in 1945 (Table 74). Such a regression, while it is a little difficult to understand since the dietary conditions were practically the same, may represent merely a periodic fluctuation; a further survey is planned for 1951. The work which has been done indicates that the general betterment in the structure of deciduous teeth in children in London County Council Schools is due to the priorities of milk and eggs and the vitamin supplements during the ante-natal and post-natal life of the children.

TABLE 74

CARIES-FREE CHILDREN AND CARIES-FREE TEETH AMONG LONDON 5-YEAR-OLDS

Year	Children			Teeth	
	Total No Examined	Percentage Caries free (i e with no D.M.F Teeth)[1]	Percentage Caries free plus those almost Caries free	Total No of Teeth	Percentage Caries free
1929	1,293	*	4 7		
1943	1,870	14 9	24 2	36,196	69 9
1945	691	24 2	28 1	13,331	73 5
1947	1,590	28 1	37 5	30,839	79 7
1949	692	14 9	24 9	13,328	73 3

[1] The percentage of caries-free children at this time was negligible D M F. = diseased, missing or filled

Many dental authorities regard dental decay as essentially a disease resulting from local conditions in the mouth and claim the specific factor to be the *bacillus lacto-acidophilus.* This cannot rule out the fact that the nutrition of the teeth is maintained by the blood and lymph in the dental pulp. It has been suggested that the dentinal cells, the odontoblasts, as part of their metabolic activity secrete lymph or a lymph-like fluid, which, passing through the extremely fine dentinal tubules, nourish both dentine and enamel (Bödecker). In infants and children the dental pulp is much more vascular than in adults; a fact which explains how readily nutritional deficiencies and diseases leave their mark on the teeth of young people. While,

cent in 1929. In 1943, 22 per cent, in 1929, 4·7 per cent of children had caries-free teeth; the improvement is undoubted.

The dental condition of 5-year-old children was again investigated by Lady Mellanby and Dr. Helen Mellanby in 1947 and a marked improvement over the 1943 and 1945 surveys was found. This they thought to be mainly due to the fact that for the first time in these surveys the diet had been of

TABLE 73

A. *INCIDENCE OF STRUCTURAL DEFECTS IN DECIDUOUS TEETH*

(*M Hypoplasia.*) (Mellanby and Couloumos)

Year	Number of Children	Percentages of Children showing			
		Normal	Slightly Defective	Defective	Very Defective
1929	1139	0	7 8	33 6	58 5
1943	1571	1 2	18 1	47·4	83 3

B. INCIDENCE OF DENTAL CARIES IN DECIDUOUS TEETH

Year	Number of Children	Percentages of Children showing			
		No Caries	Little Caries	Some Caries	Much Caries
1929	1293	4·7	11 7	20 8	62 8
1943	1604	22·4	25 9	22·4	29 3

consistently better calcifying qualities over the whole ante-natal [illegible] survey was carried [illegible] smaller sample of [illegible] ıcted in the same way and according to the same standards as in previous surveys. It was found that the gradual improvement which had been noted during the previous surveys was not maintained, that proportionately fewer children were caries free—namely 14·9 per cent—than on the two previous occasions when the figures were 28·1 and 24 2 per cent respectively. The position had

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pre-school child is in the same unfortunate position. Not until dentistry is concerned with the ante-natal as well as the post-natal care of the teeth, and is given full opportunity to meet the dental needs of pregnant women and nursing mothers can there be any hope for the future dental health of the nation. Education of mothers, at child welfare and dental health centres, and of school children in the elementary principles of nutrition, should include instruction in the nutrition and care of the teeth. Dental health education will be the more impressive if the dental service in schools and elsewhere is equal to the requirements which education will and should demand of it.

The relationship between nutrition and dental health is indubitable. That some children, upon excellent diets supplemented by cod-liver oil and nutritive salts, do not avoid caries is no argument against the part played by food; it is but evidence that good nutrition is not entirely dependent upon diet, but demands good digestion, absorption and assimilation: and the quality of these functions, like the quality of the teeth, depends in no small measure upon hereditary influences.

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CHAPTER XX

THE APPRAISAL OF THE NUTRITIONAL STATE IN INDIVIDUALS AND COMMUNITIES

Appraisal of the Nutritional State in Individuals and Communities.—To appraise the nutritional state or to evaluate the condition of nourishment of individuals or communities is a task beset with many difficulties. There are several methods of attempting to assess the state of nutrition in an individual or community: dietary surveys indicate the potential nutritional state of a community: a study of vital statistics, purely objective, gives a broad comparative picture more of national groups than of communities; the growth and development of children affords a valuable criterion for assessing the state of nutrition, as also the nature of the social environment in which the children are reared; clinical examination, more immediate and direct, is beset with the difficulties attendant upon any subjective study; scientific methods involving physiological and biochemical tests are in the main strictly objective but at present far from complete.

Dietary Surveys.—While of little importance at present in assessing a potential or latent deficiency dietary surveys will, in conjunction with clinical and biological methods, indicate some degree of correlation of disease with the lack of specific nutrients. The results of such surveys have been fruitful in offering definite reasons for the presence of malnutrition and deficiency disease in communities and among certain races; and they may be of value in determining whether or not a potential deficiency exists. To do this, however, the development of the signs and symptoms of deficiency would have to be *carefully observed in relation to given levels of intake of specific* nutrients in various dietary patterns and in numerous communities. No community and few individuals have ever been maintained on dietaries in which subminimal amounts of one or more *nutrients were kept at pre-determined levels.* Experiments in which specific additions have been made to minimal diets, for example those of Dr. Corry Mann on boys in an industrial institute and of many investigators on school children,

have indicated the beneficial effects of added nutrients upon growth in terms of increased height and weight. It would appear, that as a practical indicator of the presence or possible appearance of under- or mal-nourishment, economic and dietetic evidence is of definite value. The recent work on vitamin synthesis would lead one to conclude that by present methods of dietary survey no complete answer would be forthcoming concerning the *minimal* dietary requirements necessary to prevent deficiency disease in communities of human beings. The difficulty lies in the fact that it is impossible to draw a sharp distinction between the normal and abnormal in communities or individuals. In dealing with the practical problems of nutrition it is best to adhere to the clinical meaning of the word normal which has been defined by Ivy, who states that " anyone is normal who is well and not handicapped by some disturbance manifested by symptoms ". This means that the mild imperfections of the body should be regarded as not outwith the normal. In all its functions, normal and even abnormal, the body is constantly maintaining or attempting to maintain a physiological mean Many apparently healthy people, while not normal, are not significantly abnormal. Only when physiological adaptations definitely fail, is the significantly abnormal state entered upon, and from that, the subject may, and often does recover, without having been aware of any departure from the normal. Biomicroscopic and X-ray examinations frequently prove this statement. Just as one cannot accurately define the normal in health, so one cannot define the optimum in dietary intake. Many years ago Chittenden stated that the smallest amount of food which would serve to keep the body in a physiologically efficient state would be, not only the most economical but the optimum, and that anything over that amount would be injurious. While nothing is gained by an excess in food intake, Chittenden's minimum left little or no margin for the ever changing needs and the many unknown adaptations of the body. The term optimum is of little practical value and in view of the difficulty of fixing a standard of perfection, the term adequate, in relation to prescribed nutrients for known conditions, seems to be the most useful. In a word, the term adequate implies the optimal, that is, the best in the supply of nutrients to meet the requirements of the individual. How difficult it is to estimate the requirements of individuals is not

sufficiently appreciated. How often is it forgotten in discussing growth, that full consideration should be given not only to bones and muscle but to germ plasm. Little is known as to the specific requirements of the germ plasm in terms of nutrients. It is known that when growth is poor, the progeny become smaller and ultimately the strain dies out. That this is true of man is borne out by the appearance and disappearance of certain races, tribes and communities. Some races are tall, healthy and long-lived; others are puny, disease-ridden and prematurely senile. Heredity does, and always will, play an important part in determining human stature and health; climate also plays a part, even if a small part, in determining physiological characteristics, and it must now be accepted that diet also plays its part, a fact which in the opinion of some outweighs both heredity *and climate combined. One of the most interesting reports on* the part played by diet in racial development has been referred to, namely the study of the Kikuyu and Masai tribes in Kenya (Orr and Gilks). The comparative results given in that report are not confined to Kenya, they can be obtained throughout India, where various races subsisting on different diets give great opportunity for work on the numerous problems associated with nutrition and national health. The diets of Bengalis, Sikhs and Pathans vary in certain respects, and again one can see how diet must play a part in the development of physical and mental characteristics of people. Major-General Sir Robert McCarrison, I.M.S., late Director of the Pasteur Institute at Conoor, India, examined the diets of six different races, feeding series of standard rats on the various diets, the rats being kept under precisely the same conditions. The following table speaks for itself:—

Diet	*Average body weight of the group*
Sikh	235 grams
Pathan	230 ,,
Maharatta	225 ,,
Kanarese	185 ,,
Bengali	180 ,,
Madrassi	155 ,,

It is clear that there must be a radical difference between the diet of the Sikh and the Bengali or Madrassi. The Sikh diet is the most nutritious in India; it is made up of freshly-ground whole wheat (atta), which is made into chapattis (cakes

of unleavened bread), milk, butter, ghee (i e boiled, clarified butter), curds, buttermilk, dhal (legumes), vegetables, potatoes and root vegetables, with fresh meat and water. Beef of the cow is never eaten, the animal being regarded as sacred. The Madrassi diet, the least nutritious, consists of washed, polished rice, dhal, fresh vegetables, condiments, vegetable oils, coffee with sugar and a little milk, a little buttermilk, very little ghee, cocoa nut, betel nut and water. Sir Robert McCarrison states that rats fed on the Sikh diet live to an old age; they suffer no infant mortality and by attention to cleanliness, comfort and food, disease has been almost completely eliminated In fact, in many cases the rats far outlived their normal two-year span of life and had to be killed.

An adequate diet, frugal living, sunshine and constant movement are invariably associated with strength and stamina. "Wherever there are dairy animals in abundant proportion to the population and their products form the staple articles of diet, fine physical development is seen without exception" (McCollum). The pastoral Arabs, noted for their physique, live on milk from goats and sheep, meat, cereals and dates. The milk is always soured to preserve it and is eaten as curds. Without milk they would not survive in the physical condition in which we find them to-day. Tall, thin, alert, robust and virile, the pastoral Arab is in many cases almost a perfect specimen of humanity. Simple, abstemious, living to a ripe old age, proud and often hungry, these wandering people are an object lesson in nutrition. So it is with the pastoral peoples of India, living largely on a diet of milk, butter, ghee, fruits and vegetables, they are vastly superior in physique to most of the other classes of Indians. A similar story can be told of the people of Skye, Lewis and other Hebridean Islands, who subsist on cods' livers, fish, turnips, potatoes, oatmeal and milk. Any departure from these simple but adequate foodstuffs which allows the inclusion of rich carbohydrate foods, highly-prepared cereals, tea and cakes, leads ultimately to a deterioration in the structure and strength of bones, teeth and muscle.

Vital Statistics.—Vital statistics, particularly those relating to infant mortality, neo-natal mortality and post-natal mortality, that is the death rate from the second to the twelfth month, are of importance in arriving at a general assessment of the factors upon which the viability of children depends.

Experiments upon animals and experiments performed unconsciously by various races upon themselves show clearly how important are hereditary and environmental factors in the survival of children during the first twelve months of life. The lack of essential amino-acid bearing proteins, energy foods, vitamins and mineral salts, added to bad social conditions, leads to malnutrition, and malnutrition is a serious handicap to children; that this is so is shown by comparing the death rate of infants under 1 year, under 4 weeks and in the period from the second to the twelfth month. The figures in Table 75, giving a comparison of infant mortality rates for England and Wales, and Scotland from 1885 to 1948 illustrate this point. In the quinquennium 1881–85, the infant mortality rate for England and Wales was 139, for Scotland 118 per thousand live births. The situation has improved steadily since then and the figures for 1950—England and Wales 30 and Scotland 39 per thousand live births—indicate the steady, continual improvement which has been taking place in this country since those days in the middle of the twentieth century when the public conscience was thoroughly aroused concerning infant mortality and the unhygienic conditions under which many working people lived. With regard to neo-natal mortality, the factors causing death in the first month of life are not so readily controlled as are those which operate from the second to the twelfth month. The progress made in controlling the environmental factors which operate during the post-natal period is shown in the figures in the last two columns of Table 75.

The death rate in the neo-natal period is due largely to factors [illegible] cy depends. [illegible] e of social [illegible] " the most [illegible] s to lessen the incidence of prematurity" . . . . " The excess of neo-natal [illegible] income groups are examined. The highest mortality rates " are invariably associated with poor social and economic conditions affecting adversely the physique, health and nutrition of the mother ". It has also been shown that toxæmia of pregnancy is less common in the better nourished sections of communities.

Indeed wherever we may look, be it in the East or the West, one realizes that diet is undoubtedly an important factor in maintaining maternal health (Ebbs *et al.*, 1941 and 1942)

During 1942 a record was made by Cameron and Graham of *the food intake of 300 women attending the Glasgow Maternity* Hospital, made up as follows: 100 mothers of still-born infants,

TABLE 75

A COMPARISON OF THE INFANT MORTALITY RATES FOR ENGLAND AND WALES AND SCOTLAND FROM 1885 TO 1948

Year	Infant Mortality under one year		Neo-natal Mortality under four weeks		Infant Mortality from 2 to 12 months	
	England and Wales	Scotland	England and Wales	Scotland	England and Wales	Scotland
1881-85	139	118	—	—	—	—
1901-05	138	120	—	—	—	—
1921-25	76	92	—	—	—	—
1931-35	62	81	31	37	31	44
1936-40	55	76	29	37	26	39
1938	52	72	28	36	24	36
1939	50	69	28	36	22	33
1940	57	78	29	37	28	40
1941	60	83	29	40	31	43
1942	51	69	27	35	24	34
1943	49	65	25	33	24	32
1944	45	65	24	33	21	32
1945	46	56	25	28	21	28
1946	43	54	24	29	19	25
1947	41	56	23	28	18	28
1948	34	45	20	25	14	20
1949	32	41	19	23	13	18
1950	30	39	18	23	12	16

100 mothers of premature born infants, and 100 mothers of full-time infants. The average daily Calorie intakes in these groups were 1644, 1710 and 1946 respectively. The diet of the mothers with full-time infants was superior in every respect, particularly in first-class protein, calcium and phosphorus. However incomplete the evidence may be of a steady improvement of the nutritional state of the nation it will be generally agreed that "the neo-natal and infant mortality rates will be most substantially improved by improvement in the standard

of health and nutrition of the mothers of the lower income groups and they constitute the vast majority" (Baird). Malnutrition is not only a matter of diet, otherwise it would never be seen in the children of the upper classes. Bodily defects, sleep, exercise, economic conditions and heredity play their part, but, as has been pointed out, they do not surpass in importance the part played by diet. Hereditary influences can be removed or modified and the hardships of environment the better withstood

TABLE 76

INFANT MORTALITY RATES

Deaths per Thousand Live Births

Quinquennium or year	England and Wales	Scotland	U S A	Canada	Australia	New Zealand	Holland
1881–85	139	118	—	—	125	91	181
1901–05	138	120	—	—	97	75	136
1921–25	76	92	74	—	58	43	64
1931–35	62	81	59	—	41	32	45
1936–40	55	76	51	63	39	32	37
1939	50	69	48	61	38	31	34
1940	57	78	47	56	38	30	39
1941	60	83	45	60	35	30	43
1942	51	69	40	54	39	29	40
1943	49	65	40	54	36	31	41
1944	45	65	40	55	31	30	47
1945	46	56	38	51	29	28	79
1946	43	54	34	47	29	26	41
1947	41	56	32	45	28	25	33
1948	34	45	32	44	28	22	29
1949	32	41	31	43	25	24	27
1950	30	39	29	—	—	—	25

by communities and races if attention be paid to the correct feeding of mothers and children. The first step in combating the evils of malnutrition is the ante-natal care of the child.

Growth and Development.—Since the war, there has been a marked increase in the rate of growth of children in Great Britain as also in the U.S.A., although the adult height has not appreciably changed. Several anthropometric measurements have been added to the simple ones of height and weight; the commonest indices used or suggested are those which express weight as a function of height, relate chest measurement to

height, chest and arm girth to hip width, bi-acromial breadth, etc. As a means for the nutritional assessment of children these have their limitations. Hereditary and environmental factors—nutrition, poor housing, lack of sleep, infectious disease—are so inextricably inter-related in determining the growth and development of children that all anthropometric indices must be viewed with caution. Undoubtedly the growth and development of children are of value as criteria in the assessment of the nutritional state, as they are also of environmental conditions, but little is yet known of the various factors upon which growth depends, of the part played by nutrients in enhancing it or of environmental conditions in controlling it. The indices (Tuxford) and grids (Wetzel) still await evidence of satisfactory statistical correlation with clinical findings or the "grading points" of posture, muscular development, etc., suggested by Sydenstricker, Magee, Sinclair and many others. It is not to be inferred that heights and weights accurately determined are without value, for by them investigators of the Ministries of Education and Health have shown that during and since the the war school children are certainly not below their pre-war counterparts in the matter of height and weight. Taken as a whole, the conclusion arrived at from an analysis of the data is that the growth rates and physique of children in various social grades, improving before the war, have been maintained or even improved upon during the war years.

That these general conclusions are true is proved by reports of school medical officers and surveys such as those carried out by Dr. Bransby on children between the ages of 5 and 15 years. These surveys, commenced in 1936 and continued since, have shown that in certain localities the average heights and weights showed small regressions during the years 1940–1–2, that such regressions were generally observed in the older children (12 years of age) and that they were on the whole made good by 1943. The magnitude of the changes in height and weight of children between the pre-war period and 1944 was estimated by calculating for 21 areas of Great Britain the average change for the age groups 5 to 15 years inclusive. For boys and girls the average increase in height was ¼" to ½" and in weight 1½ to 2 lb. A special inquiry made by the Ministries of Health and Education from 1940–45, limited to boys and girls within the age range of 9 to 14 years, showed similar increases in height and

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weight; for boys and girls the increase in height was of the order of ½", being somewhat greater for girls than for boys, and in weight it was 1–1½ lb. for boys, 3–3½ lb. for girls, that is, somewhat less than 1 per cent of the attained height and about 2 per cent for boys and 5 per cent for girls of the attained weight.

It must, of course, be noted that with regard to the growth of children their physique was improving steadily before the war. This is shown by a comparison of the heights and weights of London elementary school children in 1905–12 and 1938, where considerable improvement was seen at all ages. It is possible that the wartime improvement in physique was merely a continuation of the pre-war process. In certain localities, particularly in blitzed areas, the rate of improvement was retarded, but in most cases, by 1943–44, the rate of improvement would appear to have increased until about 1947, when there was again evidence of a slight retardation. To judge the effect of the war it becomes necessary to compare the rate of improvement actually achieved in a post-war period with that which might have been expected had the pre-war rate been maintained.

It is true that to-day children and adolescents are taller for their age than they were ten years ago. While there is no evidence that the average height of men and women has increased, there is evidence that the rate of growth of children has increased. This may be due to the better distribution and greater consumption of milk, meat, cereals and vegetables than obtained a decade ago. It has always been apparent that the children in the higher income groups in Britain, Scandinavian countries, North America, Australia and New Zealand, whose diet is rich in animal proteins, mineral salts and vitamins are generally tall and healthy This is borne out by a recent study in France (Trémolières *et al.*, 1950) which shows that defective feeding prevents the attainment of the potential adult stature. A diet adequate for the needs of growth would therefore lead to a higher national average of height and weight by the disappearance of the undersized. If the increased rate of growth ultimately results in an average height of men and women approaching that of the taller and better fed groups of the past, one would be justified in concluding that a better nutritional status had been achieved.

Considerable attention has been paid to the amount of subcutaneous fat of the body as a criterion of the nutritional

state. Deviations in the weight of individuals are generally due to variations in the amount of body fat. Prolonged undernutrition leads to a loss of subcutaneous fat, of interstitial fat and of fat from those parts of the body where fat tends to accumulate (abdomen, buttocks, etc.). As a criterion of increase or decrease of body fat, the relative body weight, that is the weight of the subject as a percentage of the normal for the age group, is of little value within the normal range of weight variation. To estimate the nutritional state of an individual by pinching a fold of skin is a very old clinical procedure. It is indeed a rough measure of the nutritional state and of the adequacy of the diet in terms of Calories. In an attempt to measure with some degree of accuracy the thickness of the fold of skin, Richer (1890) constructed a caliper which has been used by several investigators interested in determining changes in subcutaneous fat due to a variety of clinical conditions (Lehmann *et al.*, 1893; Oeder, 1910; Batkin, 1915; Käding, 1922; Lauter and Terhederbrügge, 1937–38). Such investigators showed that, although persons of normal body weight exhibit large differences in the amount of their subcutaneous fat, there were definite changes in subjects suffering from malnutrition, tuberculosis and disturbances of fat metabolism. A step forward in skin-fold measurements was made when Franzen (1929) constructed a caliper with a spring to maintain pressure against the skin and increase the accuracy of the measurements. For such estimations to be of any value the strength of the spring of the caliper should be known, that is to say, the force which it may exert at varying distances between the jaws, and also the extent of the contact surface, in order that the actual pressure per mm. recorded should be known. More recently, Sinclair (1948) had noted the usefulness in nutritional surveys of skin-fold measurements, the points of measurement being on the upper arm and forearm. By using a special caliper "sprung" so that the pressure applied is constant in every case, Dr. P. J. Cowin and Dr. W. T. C. Berry (1950) have estimated subcutaneous fat of school children in the course of nutritional surveys. The width of the skinfold produced by grasping firmly between the thumb and forefinger the skin over 5 points of the body, is measured by inserting it between the arms of the caliper. The 5 points are: (1) the front of the arm mid-way between the head of the humerus and

the anticubital fossa, with the forearm slightly flexed and supinated; (2) a corresponding point on the back of the arm; (3) just below the angle of the scapula, with the arm held to the side of the body; (4) just below the costal margin in the mid-clavicular line, and (5) 1 inch to the right and below the umbilicus. All these folds are vertical except the third which is diagonal, and the sum of the 5 measurements is used to indicate the amount of fat on the body. Many investigators have regarded skinfold measurements as of some value in supporting clinical impressions concerning the nutritional state of individuals; others, however, do not regard the method, as yet developed, as affording a reliable estimate of the nutritional state (Keys *et al.*) (see "Symposium on Growth", 1951).

Signs of Under- or Malnutrition.—Malnutrition in this country has generally been associated with a dietary régime of white bread, cereals and tea, to which are added potatoes and occasionally minimal amounts of meat of poor quality. The deficiencies to-day are in those foods which give first-class proteins, minerals and vitamins, namely, milk, good quality meat, eggs and vegetables. While many children are quite fat on such a diet, they are by no means healthy. Examination of their bones, teeth and muscles reveals grave defects, which sooner or later manifest themselves in disease, deformities and chronic ailments. These children are subject to all the minor and major ills which affect the young; anæmic, listless and without resistance to infectious disease, they are much more apt to succumb, when seriously ill, than those who have been fed on even very moderate amounts of milk and vegetables. While some are fat and flabby, others are thin and manifestly not fit; while some are over normal weight, others are well below it. Their posture is that of fatigue, namely, round shoulders, sagging head and protruding abdomen. Such children have no sparkle, they are listless, their eyes are lustreless, often sunken, and their facial expression and general restlessness are indicative of the lack of joy in life which is so often the lot of the badly fed. Weight by itself should not be accepted as an indication or index of physical fitness. Any change in weight which is 10 per cent under or over the normal for the age and height, for both are important, should not be disregarded. Under-nutrition occurs readily in youth when the body is or should be growing rapidly, and it may be produced in several

ways apart from an inadequate diet. For example, digestion, absorption and utilization of the foodstuffs may be deficient; oxygenation of the blood may be reduced by reason of a poor development of the chest or by the presence of diseased tonsils and adenoids; lack of exercise in a sunless and non-hygienic environment may lead to a loss of vitality.

The Signs of Good Nutrition.—Good nutrition is always associated with a well developed body, which is not far from the average in weight and height for the age of the subject. The muscles are firm and not lacking in a fair covering of subcutaneous fat. Posture affords good evidence of the state of nutrition. A well-nourished person will stand erect; there will be no drooping shoulders nor winged shoulder blades, no flat chest nor large abdomen. The facial expression will be either calm or alert; the hair will be glossy in texture and abundant in quantity, and the eyes clear and bright. General health, digestive functions and the quality of sleep enjoyed will invariably be good. All this stands in marked contrast to the picture of the badly-nourished child, who is undersized, of poor physical development and whose muscles always lack that covering of fat which produces the plumpness of the well-fed child.

Related Causes of Under-nutrition.—One must not be blind to related causes of under- or malnutrition. A sufficiency in the fulfilment of dietary needs may be futile or productive of but poor results if hygiene be not instituted, discipline maintained and ignorance dispelled. Poverty, while a veritable cause of malnutrition, may not always be the chief factor. In many homes where essential foods, milk, fruits, meat and vegetables are not lacking, but where parental discipline is entirely lacking, are to be found children who are under weight, thin, anæmic and without vigour. They are essentially cases of under-nutrition. Children who are left to express themselves as their temperamental minds may dictate, and are allowed to select foods as rich as they are lacking in vitamins or body-building proteins, may often show signs of under-nutrition. Parental control must be exercised in matters of diet just as in matters of education. The wilful child who refuses to drink milk or dallies at meals so that it lacks nutriment in the midst of plenty, can be disciplined to regularity and alacrity in eating, if parents will but take the trouble, and it may be considerable trouble, to maintain a dietary discipline. While

on the matter of parental control, it may be pertinent to emphasize the importance of over-fatigue as a cause of defective body building. Prolonged stimulation of a boy or girl to work much longer than usual in order that he or she may attain a certain position in school is entirely wrong. Many a boy with a mental capacity 60 per cent of the normal, is urged to extra work with the suggestion that he is bound for the top of his class, or sure of a certain prize, if he but works hard; when such a boy is urged to emulate those of 80 or 100 per cent capacity, he is being most unfairly handled. While temporary success may crown his efforts, it is almost certain that he will ultimately realize his limitations. If he does so and sets the pace accordingly, no harm may be done. If, however, he or those who guide him do not, then physical and mental breakdown may follow rapidly upon the heels of such an endeavour strain, and, if this be associated with poor feeding, the complications attendant upon malnutrition will prevent a rapid return to normal.

The Appraisal of the State of Nutrition in School Children.—The evidence of undernutrition in this country, admittedly all too brief in its presentation here, is sufficient to call for continued and concerted action, on the part of central and local authority, in facing the problems of nutrition. The facts, however, have produced neither a yardstick nor a formula by which nutritional status could be measured. There is nevertheless sufficient in clinical, biochemical and somatometric methods to permit of a good approximation in its measurement.

...thods have been employed in ... of children and adolescents, ... *labour of teams of clinicians,* scientists and nutritionists, that the results are, in certain quarters, considered not to be commensurate with the amount of work entailed. Having considered carefully ways and means ...

... were concerned, ... emical methods, ... "a general impression of the state of fitness, both physical and mental, conveyed to an experienced clinician following upon a detailed examination".

Brief reference can be made here to certain results of this survey of school children in Scotland, carried out by the Sub-Committee on Nutrition in 1944–45. The child population of Scotland numbers about 1½ millions. Approximately 3300 children, "entrants" (5–6 years) and "leavers" (12–13 years), from four cities and three county areas, were examined. Selection in the case of the county areas was of children from homes in which the bread winner was engaged in one or other of three occupations or industries which are characteristic of the area—heavy industry, light industry, fishing. While the sampling was guided by practical considerations rather than by the ideals of random sampling, the selection was sufficiently diffuse to present data suitable for a general comparison with past surveys. It was found in 1944–45 that the state of well-being of *an individual* child bears no consistent relationship to the attained height or weight and that therefore the assessment of well-being is influenced by clinical findings and not by physical measurements. This but corroborates the statement that the most practical method of assessing the state of nutrition, or better, the state of well-being, will ultimately demand a combined clinical and biochemical examination. It was, however, found that measurements of average heights and weights together or of weights alone, are, for *groups* of children, closely correlated with the state of well-being as assessed clinically (Table 77).

In comparing rates of growth, it was noticed that boy "entrants" were taller and heavier than girl "entrants" and girl "leavers" taller and heavier than boy "leavers". This means that the average rate of growth in height and weight of girls exceeds that of boys about the 11th year, and that there is again a reversal in the relative growth rate at about 14½ years of age (see Fig. 17).

The most important facts in Table 77 are to be found in the last two columns. It will be noted, in comparing each of the eight groups in the 1937 and 1944 groups (underlined), that the average heights and average weights have increased. In comparing the 1934 and 1937 results there will be seen the only decrease recorded: it is a decrease in weight of girl "entrants" in 1937, of 0.60 lb. The important fact, however, is that, during the greatest war in history and during a period in which there was a more even distribution of food accompanied by

increased purchasing power for the pre-war lower income groups, the boys and girls, in a fairly representative sample from Scottish schools, showed a substantial increase in both height and weight. This is a small but clear piece of evidence proving the value of the methods adopted by the Government for the supply and equitable distribution of food during the war. The data in this

TABLE 77

AVERAGE AGE, HEIGHT AND WEIGHT OF CHILDREN EXAMINED BY THE EDUCATIONAL HEALTH SERVICES OF THE CORPORATION OF GLASGOW 1934-35, ROWETT RESEARCH INSTITUTE AND CARNEGIE TRUST 1937 AND THE NUTRITION SUB-COMMITTEE OF THE DEPARTMENT OF HEALTH FOR SCOTLAND 1944-45

Category	Time	Average Age yrs mths	Average Height ins	Average Weight lb	Average Height adjusted to 5½ yrs and 13½ yrs	Average Weight adjusted to 5½ yrs and 13½ yrs.
			ENTRANTS			
Boys	1934	5 3·97	41·43	39·73	41·71	40·46
,,	1937	5 6·00	43·11	41·25	43·11	41·35
,,	1944	5 6·90	43·32	41·89	43·19	41·56
Girls	1934	5 4·22	41·12	38·14	41·42	38·71
,,	1937	5 8·00	41·73	38·17	41·70	38·11
,,	1944	5 6·94	42·82	40·44	42·66	40·14
			LEAVERS			
Boys	1934	13 5·39	57·01	82·07	57·11	82·58
,,	1937	13 6·00	57·68	86·60	57·68	86·60
,,	1944	13 7·18	59·22	89·45	59·03	88·46
Girls	1934	13 5·48	57·69	85·88	57·76	86·29
,,	1937	13 5·00	58·66	88·10	58·79	88·83
,,	1944	13 7·10	59·74	94·20	59·60	93·34

report would tend to indicate, among other things, that a state of well-being in children is correlated with efficiency of the mother, participation in organized games and membership of youth organizations.

Clinical Examination.—Medical inspection of school children was introduced by the Board of Education in 1907. The methods were revised in 1934 and are still used by school

medical officers; the inspection amounts to a general examination of the children and an assessment of muscular development and physique, from which an approximate appraisal of their nutritional state is arrived at; the method has always included measurements of height and weight. It is well known that school medical officers and all who make subjective observations, or even objective estimations, are never quite consistent with one another and often are equally inconsistent in their individual appraisement on subsequent examination. The subjective appraisement of the nutritional state depends to a large extent upon the type of individual with whom the investigator is generally associated, as also upon the physique and well-being of the investigator himself.

In order to determine whether rationing during the war had adverse effects upon the nutritional state of the people of this country, rapid clinical surveys were carried out in 1942 at the instigation of the Ministry of Health by Dr. Sydenstricker of the U.S.A. His method was to inspect the skin, hair, tongue mucous membrane of the mouth, to make slit-lamp examinations of the cornea and scleral conjunctiva and to note certain factors concerning the condition of the teeth. Neither general physical examinations nor laboratory tests were made. The "general physical status", as it was termed, was noted and subdivided into three categories—good, satisfactory and poor. Many similar rapid surveys have been made (Adcock, Magee and Milligan, 1947; Adcock, Hammond and Magee, 1947, etc.), slightly different terms being used in place of "general physical status", such as "nutritional state", "grade of nutrition", "clinicians' nutritional grading", "grading criteria". In evaluating the nutritional state the clinicians took account of a number of criteria—posture, tone of muscles, elasticity of the skin, expression; the clinical signs noted were folliculosis, gingivitis, corneal vascularization, pityriasis, cheilosis, angular stomatitis and enlarged tongue papillæ. Numerous data collected in these clinical surveys were statistically analysed to determine if any relationship existed between the grade of nutrition and the incidence of clinical signs (Adcock, Hammond and Magee, 1947) The data from nutritional surveys of 3351 children aged 8 to 15 years and of 3326 adults of both sexes were analysed statistically to ascertain if a relationship existed between the gradings "good", and "fair" and "poor" combined

increased purchasing power for the pre-war lower income groups, the boys and girls, in a fairly representative sample from Scottish schools, showed a substantial increase in both height and weight. This is a small but clear piece of evidence proving the value of the methods adopted by the Government for the supply and equitable distribution of food during the war. The data in this

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Category	Time	Average Age yrs mths	Average Height ins	Average Weight lb.	Average Height adjusted to 5½ yrs and 13½ yrs.	Average Weight adjusted to 5½ yrs and 13½ yrs.
			ENTRANTS			
Boys	1934	5 3 97	41 43	39 73	41 71	40 46
„	1937	5 6 00	43 11	41 25	43 11	41 35
„	1944	5 6 90	43 32	41 89	43 19	41 56
Girls	1934	5 4 22	41 12	38 14	41 42	38 71
„	1937	5 8 00	41 73	38 17	41 70	38 11
„	1944	5 6 94	42 82	40 44	42 66	40 14
			LEAVERS			
Boys	1934	13 5 39	57 01	82 07	57 11	82 58
„	1937	13 6 00	57 68	86 00	57 68	86 60
„	1944	13 7 18	59 22	89 45	59 03	88 46
Girls	1934	13 5 48	57 69	85 88	57 76	86 29
„	1937	13 5 00	58 66	88 10	58 79	88 88
„	1944	13 7 10	59 74	94 20	59 60	93 34

report would tend to indicate, among other things, that a state of well-being in children is correlated with efficiency of the mother, participation in organized games and membership of youth organizations.

Clinical Examination.—Medical inspection of school children was introduced by the Board of Education in 1907. The methods were revised in 1934 and are still used by school

comparison whereby to appraise the effects that have been produced upon the population during and after the second world war. The method which received most attention during the war was that of the estimation of hæmoglobin in the blood. The Committee on Hæmoglobin Surveys of the Medical Research Council studied the possible methods to be used in large-scale surveys and recommended the Haldane-Gowers method. It is a method widely used, well known to all investigators and is capable of accurate standardization. However, it requires experience if reliable and comparative results are to be obtained. During the war it was found by the Haldane method that there was an improvement in the hæmoglobin content of individuals between 1942 and 1945. Davidson and his co-workers (1944) and Roscoe and Donaldson (1946) found that the hæmoglobin level among school children and pregnant women in Edinburgh rose between 1942 and 1944. The betterment in children Davidson took to be due to eating much of the national loaf which contained more iron than white bread. With respect to adolescents, the Hb-levels were also satisfactory; the figures of Davidson *et al.* (1943) were lower than those of Wills *et al* (1942). An extensive survey carried out by the Medical Research Council showed hæmoglobin levels of certain sections of the population which compared favourably with those obtained elsewhere at different times While certain observers, such as Fullerton *et al* (1944) in Aberdeen and Cook *et al.* (1944) in Dundee, have found low values among adolescents and nursing mothers, it may be accepted that the evidence as presented indicates a slight rise in the mean hæmoglobin content, particularly of boys and girls, compared with what obtained previous to 1942.

Attempts have been made to determine whether or not the ascorbic acid content of the blood bears any relationship to the state of nutrition, but the fluctuations both in the intake of ascorbic acid and in its blood content make for great discrepancies in the results obtained. The Oxford Nutritional Survey found very low levels of plasma ascorbic acid in certain groups of people at certain times of the year, the mean value being for males between the ages of 20 and 24 years in Accrington, in January–February 1942, 0 08 mg , and for males in Merthyr Tydfil, in June–July 1942, 0 09 mg./100 ml.: male students in the same age group gave a mean of 0·16 mg./100 ml. in February–

as one category—"poor", and the incidence of the clinical signs observed at the time of medical examination but not taken into account in grading the subjects. The analysis showed negligible correlation between the clinical signs singly and collectively and the clinicians' nutritional grade. A special survey of 1067 children was carried out to determine if any relationship existed between the grade of nutrition and the "grading criteria"—posture, muscular development, diminished subcutaneous fat, pallor, mucous membrane pallor, etc.—which the *clinician takes into account but does not as a rule* record in deciding the nutritional grade itself. For the grading criteria there was a high degree of correlation between each one and the combined pool of all the criteria. The clinical signs showed only negligible correlations with each other, with the nutritional grade or with any of the grading criteria. It would seem that nutritional assessment as at present understood is mainly determined by the value placed on the grading criteria —posture, muscular development, etc.—and to a negative *extent, or not at all, by the presence or absence of clinical signs* —gingivitis, corneal vascularization, pityriasis, stomatitis, etc.

The results of special rapid surveys by the Ministry of Health have been published regularly in the monthly Bulletin of the Ministry, and the figures as a whole provide evidence of the absence of severe malnutrition or of unfavourable changes in [illegible]

in "*The State of Public Health during Six Years of War*", *it is* nevertheless true that, while the vulnerable groups were well protected by official action and still are, the adolescents of the war years, especially those not benefited by industrial rations, were not adequately cared for.

Scientific Methods.—While laboratory methods of investigating the nutritional state of individuals have not yet reached that state of precision which further research will undoubtedly produce, nevertheless there are one or two methods of approach which are of *definite value. Objective methods* are specific not only in detecting malnutrition but in determining faults in the diet which may cause malnutrition. Unfortunately, previous to the war little was done in the way of applying the strictly scientific method and therefore there is no basis of

6 63 g./100 ml., the concentration being under 6 0 g./100 ml. in one case only. Hoch and Marrack, using the technique of Chibnall and checked against estimations made in his laboratory, found in students, laboratory workers and nurses an average serum protein value of 7·43 g./100 ml with a range from 6 68 to 8 0. Dyson found a mean concentration of 6 56 g./100 ml. in 853 male and female blood donors in 1943 and a mean concentration of 6 78 in Canadian base troops in England in 1943. It was suggested that the low concentration in blood donors was due to lack of protein in the food. It is apparent from all these results that the protein content of the serum or plasma of the blood cannot be regarded, as yet, as of any value in arriving at an estimation of the nutritional state. Much more will have to be done with regard to methods of estimating plasma and serum proteins before it can be hoped to find any significant statistical correlation.

With the exception of hæmoglobin, the laboratory tests are manifestly unsatisfactory. We can only hope to arrive at a sound estimation of the state of nutrition of children and of adult communities by a combination of the clinical, scientific and other methods. Such a type of investigation has been suggested by Dr. Sinclair for use in rapid estimations of the nutritional state of populations He suggests three methods: the first includes a dietary survey, chemical examination—hæmoglobin, erythrocyte count, protein, ascorbid acid, vitamin A, carotenoids and phosphatase in serum of children; somatometric measurement—weight, height, thickness of skin and subcutaneous tissue; and clinical—examination of skin, eyes and other organs, medical history, blood pressure; the second requires special apparatus and techniques; they include the estimation of pyruvate in the blood, protein in the serum, ascorbic acid and vitamins of the B complex in the leucocytes, phosphatase in the serum, rod threshold in the dark-adapted eye, endurance tests, sitting height, pulse rate and X-ray of the hand and wrist in children: the third method includes the estimation of minerals, prothrombase clotting time and vitamins of the B complex, all in the blood, saturation tests of water-soluble vitamins, visual acuity, electrocardiograph examination, capillary and gum fragility and X-ray examination of the hand. Whether or not such a scheme is of practical value in the rapid assessment of nutrition may

March. Children examined in the summer of 1943 had much higher values in rural than in urban areas. For example, in Oxfordshire the plasma ascorbic acid in mg./100 ml. was for children from 7 to 14 years of age, urban 0·80, rural 0·93, the number of children investigated being 289 in the urban districts and 43 in the rural. In London and Birmingham the average for the same age group of 192 children was 0·47 mg./100 ml.

A better index of the stores of ascorbic acid in the body is its concentration in the leucocytes (white blood cells). In an investigation by Adcock and Fitzgerald (1945) the mean concentration of ascorbic acid in the white cells was 14·5 mg./100 ml. It is suggested that the ascorbic acid content of the leucocytes follows more closely than does the blood plasma content the amount of ascorbic acid ingested.

Similar difficulties are associated with the attempt to correlate the vitamin A content of the plasma with the state of nutrition. It is known that in subjects on a diet deficient in vitamin A and in biologically active carotenoids the level of vitamin A falls slowly, while that of the carotenoids falls rapidly almost to zero. After such a fall the rod threshold of the dark-adapted eye may rise, but considerable doubt attaches to the significance of such a rise since it does not necessarily indicate a deficiency of vitamin A ; there are many non-nutritional causes of such alteration in vision. During the war there appeared considerable divergence of opinion on the question of the part played by vitamin A in the threshold of the rods of the dark-adapted eye, and until these differences of opinion are resolved vitamin A will still remain unsuitable as a factor for the determination of the nutritional state.

The protein content of the serum and plasma has been the subject of much investigation by members of the Oxford Nutrition Survey. The results of the investigation to date, as stated by Dr. Sinclair, are that in no group was the mean concentration of serum or plasma protein below 7 g./100 ml. ; the mean concentration in serum or plasma of groups of Oxford students was found to be consistently higher than the mean concentration in serum or plasma of other groups of adults investigated, except prisoners of war.

Hoch and Marrack (1948) found that the lowest mean level in the 27th to 32nd week of pregnancy among pregnant women attending the ante-natal clinic at the London Hospital was

A and D tablets, since April 1943. Despite special publicity campaigns and much propaganda by the Ministry of Food, the demand for these supplements is surprisingly low. Figures given in Table 78 show the actual average weekly uptake of these supplements and the percentage of the potential demand from 1942 to 1949.

Table 78

VITAMIN SUPPLEMENTS

Actual Average Weekly issue compared with estimated potential demand From the Ministry of Food, Statistics and Intelligence Division

	Orange Juice		Cod Liver Oil		A & D Tablets	
	Average Weekly Uptake '000 Bottles	Uptake as per cent of Potential Demand	Average Weekly Uptake 000 Bottles	Uptake as per cent of Potential Demand	Average Weekly Uptake '000 Packets	Uptake as per cent of Potential Demand
England and Wales—						
1942	170 6(a)[1]	(c)[1]	66 5	(b)[1]		
1943	823 9	48 0	127 6	25 0	23 7	(b)[1]
1944	841 1	48 5	126 0	24 6	22 8	38 6
1945	713 2(b)[1]	40 4	112 2	21 9	22 6	38 0
1946	808 0	42 5	137 8	25 0	32 2	45 5
1947	812 0	41 2	189 3	33 0	43 7	42 1
1948	768 7	37·7	205 4	33 6	52 1	38 9
1949	722 1	35 3	192 4	30 9	48 6	37 4
Scotland—						
1942	19 7	(c)[1]	6 5	(b)[1]		
1943	90 6	37 4	14 2	20 2	2 0	(b)[1]
1944	107 3	44 4	14 8	20 8	2 3	27 4
1945	78 9(b)[1]	33 9	12 3	17 8	2 1	27 6
1946	80 2	33 0	14 0	19 6	2 8	33 1
1947	70 2	28 7	19 0	26 4	4 0	32 3
1948	63 1	24 3	19 7	25 6	5 0	27 6
1949	58 0	22 7	18 0	24 2	4 5	26 6
Great Britain—						
1942	190 3	(c)[1]	73 0	(b)[1]		
1943	913 5	46 7	142 0	24 4	25 7	(b)[1]
1944	948 4	48 0	140 8	24 2	25 1	37 2
1945	792 1(b)[1]	39 6	124 5	21 4	24 7	36 9
1946	889 2	41 4	151 9	24 4	35 0	44 2
1947	882 2	39 8	208 3	32 3	47 7	41 1
1948	831 8	36 2	225 1	32 7	57 1	37 6
1949	780 9	33 9	211 3	30 2	53 1	36 2

at present be regarded with some doubt, but it is true that the combination of clinical and scientific methods suggested is the only way whereby significant correlations may be found and a practical, as well as reliable, method or methods be determined.

THE TREATMENT AND PREVENTION OF UNDER-NUTRITION IN CHILDREN.

With regard to the dietetic treatment of malnutrition, it has been pointed out that diet must be the first consideration. To build up the body, it is necessary to supply those foods which will increase the size of muscle, the growth of strong bone and the resistance of the body to infection. This entails a diet of appropriate calorific value, containing first-class proteins and a rich supply of vitamins, the mineral salts, calcium, phosphorus and iron and many other things of which we know little or nothing. This means that the diet must consist of sugars, cereals, fats, meat, milk, eggs, vegetables and fruit. The diet *as purchased* should generally provide energy 20 per cent in excess of the needs of the normal for the age, weight and height of the subject. The degree to which any diet will fulfil the physiological needs of the body, will depend upon the capacity of the individual to digest, absorb and assimilate the required nutrients. It is important that digestive disturbances be avoided, and for this reason it is better to give three good meals per day and not to endanger appetite by eating between meals. To state that butter, cream, bacon, eggs and fruit should be given liberally was, in war as it is now in peace, a counsel of perfection. When lack of supply is the chief obstacle to an adequate diet, it is indeed a difficult problem that faces many parents, a problem affecting not only children but adolescents.

The basis of all diets should be milk. Fortunately the easily digested foods are among the best, namely, milk, eggs, butter, cream, whole grains, good quality meat and fruits, but unfortunately they are still (April 1951) in very limited supply. Useful adjuvants are cod-liver oil or concentrated preparations of vitamins A and C. Special arrangements have been made by the Ministry of Food for the supply of these vitamin supplements to children and expectant and nursing mothers. Cod-liver oil and fruit juices have been supplied since December 1941, and

state of health. It has not as yet been possible to secure an adequate supply of antiscorbutic foods for the whole population, and one is forced to the conclusion that practical considerations make it inevitable that infants should be given the most effective vitamin C concentrate available, namely, orange juice. No person responsible for the well-being of children should fail to realize the value of milk, cheese, butter and vitaminized margarine or neglect to make full use of all supplements for the prevention of deficiencies.

The Value of School Meals in the Nutrition of Children.—Few attempts have been made to relate the physical condition of school children to the nutrient content of their diet. A survey in Edinburgh (1945) of the individual dietary intake of middle class school children divided into two groups, namely, those taking and those not taking mid-day meals at school, showed, from mean consumption figures that, while a number of children did not receive their full share of rationed foods, the ration was not being unduly diverted to adults. It was further shown that children, who received meals at school, had at home an *average intake* of rationed food, which was less than that of the children having no meals at school, and the *proportion of children* receiving less than their allowance of rationed foods at home was greater in the group taking mid-day meals at school. "School dinner" children invariably received less of Calories, protein, iron and ascorbic acid at home than the non-school dinner children, but, if the nutrients of the school meal are added to the home meal intake, then the total intake, with the exception of ascorbic acid, was slightly greater than that of the children not taking meals at school. Consciously or unconsciously the meals in school became a substitute for, and not a supplement to, the meals at home. This nullifies the value of meals in school. So great are the energy and protein requirements of children that, at home, they should be given their correct share of all rationed foods; it should be impressed upon parents that school meals are supplementary and all children, as the new educational scheme develops, should be encouraged to take meals in school. It is important that education authorities should ensure that the school meal is well cooked, served hot, and supplies for children 10 years of age and over approximately: 800 Calories, 20 to 25 g. animal protein, 30 g. fat, 500 mg. calcium, 6 mg. iron, 30 mg. ascorbic acid.

TABLE 78 (*contd.*)

(*a*)[1] *Blackcurrant syrup and purée converted into equivalent bottles of orange juice.*

(*b*)[1] Owing to shortage of supplies the rate of release to beneficiaries restricted to one bottle per ration book.

(*c*)[1] No reliable estimate of potential is available, except for the United Kingdom as a whole, for which actual as percentage of potential was 21 1.

(*b*)[2] No reliable estimate of potential is available, except for the United *Kingdom as a whole, for which actual as percentage of potential was 13 9*

(*b*)[3] No reliable estimate of potential is available, except for the United Kingdom as a whole, for which actual as percentage of potential was 37 8.

Notes—

(i) The potential demand is the estimated total which would be consumed if all eligible beneficiaries took up their full entitlement.

(ii) The percentage uptake of cod-liver oil and vitamin A and D tablets is based on the assumption that all expectant mothers take the tablets in preference to the oil.

(iii) From 21st July, 1946, cod-liver oil and vitamin A and D tablets have been issued free of cost to beneficiaries

(iv) From 1st August, 1947, vitamin A and D tablets have been obtainable by nursing mothers up to 30 weeks after the birth of the child

CLASSES ELIGIBLE AND ENTITLEMENTS PER WEEK

	Orange Juice	Cod Liver Oil	A and D Tablets
Children under 6 months .	½ bottle	¼ bottle	—
Children 6 months and over, but under 5 years . .	¼ bottle	⅙ bottle	—
Expectant mothers	⅞ bottle	⅙ bottle or	⅙ packet
Nursing mothers up to 30 weeks after birth of child (eligible from 1st August 1947) . .	—	—	⅙ packet

Note.—Expectant mothers are given the option of taking either cod-liver oil or A and D tablets, but nursing mothers are restricted to A and D tablets.

These figures show that the results of the scheme have been disappointing, and that in Scotland the scheme is not very popular. It is cause for astonishment that in Scotland, with its short summer and long winter, there should not be a greater demand for those supplements which so thoroughly make good the lack of sunshine, fruit and vegetables. Vitamins play a definite rôle in promoting growth, increasing vitality, in preventing infections and generally in maintaining an optimal

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In the lean years that lie ahead the Milk in Schools Scheme and mid-day meals in school have still an important part to play in building up strong and robust children. The Ministry of Education based its 1946 estimates on the assumption that 75 per cent of the school population would obtain mid-day meals at school. This ideal has not been attained in many schools, largely as a result of delay in building dining halls and kitchens. Here is a magnificent field for the education of children in the elementary principles of healthful living, which includes, not only a knowledge of food values but of new ideas in social customs. Not only must the scheme be, as Lord Horder stated at its inception, " physiologically profitable " but " psychologically attractive ". To do this entails the appointment of fully qualified and experienced dietitians, skilled cooks and, within the framework of the scheme, the selection of teachers who would train older scholars to take an active part, and share responsibility in making a success of school meals.

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many. Statistics relating to infant mortality and the expectation of life give proof of this fact; a baby born in England in 1870 could expect to live 41 years, in 1937, 62 years, and to-day about 64 years. This means that in some 80 years, 23 years have been added to the period of expectation of life, almost equivalent to the addition of a generation to the population of England In India in 1931 the period of life expectancy for males was 27 years ; if a male child could continue to live for the first year of its life its expectancy of life rose 50 per cent, namely to 35 years In New Zealand, after 1 year the figure is 67 years. Such facts are sufficient to show that among the poorer classes in poverty-stricken countries the quantity and quality of life are so meagre that one is not surprised that in certain lands a wistful desire to hold on to life is coupled with mysticism, idolatry and a hope for final relief from suffering in some future state. The march of progress is slow; economic and political instability, misery and aggression make it so for all, because wherever these are found they have their repercussions upon all peoples, communities and nations.

There are, however, new movements afoot in the world to-day with potentialities for good and evil; the latter, more dramatic as news, tends to efface the good and thus perspective is lost and pessimism encouraged. This is reflected in world events to-day, in a world where there is far too little food for the world's population which tends to increase at a pace greater than the increase in food production. About one-third of the world's population enjoys health, wealth and well-being to a comparatively high degree; the other two-thirds live a life which is characterized by poverty, hunger, disease and premature death. If we consider the two major countries of the East, India and China, where malnutrition abounds, these facts become evident. In India, to meet the dangerous war-time situation with regard to the supply of food, a Ministry of Food was constituted in 1942 in order that action could be taken to administer all measures for the control of prices, supply and distribution of foodstuffs, to study the nutritional aspect of the diet of the people and to give guidance and advice with a view to raising the nutritional standard. Under basic plans (1946–50) the production of rice, millet and wheat has been fostered, the distribution of surpluses to deficit areas arranged, limitation of the export of oil and oil seeds enforced and the need for an

CONCLUSION

A FEW generations ago civilization seemed to be contributing nothing to the physical well-being of the working classes. The present generation has witnessed a great change. Modern methods in agriculture, transportation and scientific research all over the world have opened up for us rich and extremely varied sources of food supply. This generation has seen the newer knowledge of nutrition put into practice both in peace and war. In this country, the old dietary of white bread, tea, sugar, meat and potatoes can be intelligently corrected, by creating a better balance between the energy-producing and animal protein foods, increasing the consumption of fruit and vegetables and encouraging a greater use of milk and bread made from 80 per cent extraction flour. To-day, had it not been for the devastation wrought by insensate war, the dietary deficiency diseases of two generations ago would ere long have been eliminated from the great mass of the populations of the western world. By long and, at times, bitter experience we have begun to learn what better nutrition can do for the improvement of the health of individuals, communities and nations. The physiological requirements of man and the means of supplying them are known. In a broad measure we are aware of the missing factors in numerous dietary diseases; we are not without knowledge concerning the patterns of diet which the individual requires in order to maintain health and vigour of body; and we know the nature of the diets which lead to bodily impairment, ill-health, disease and death.

T[illegible] nutritional needs of communities and nations are known as a [illegible] kno [illegible] level of general education, the eradication of ignorance and prejudice so commonly associated with food, and a greater sense of responsibility in the more favoured nations for those who live under the shadow of malnutrition.

To look at the nutritional condition of people throughout the world is to realize how terribly inequitable is the world's nutrition balance sheet. So great is the mass of evidence of malnutrition in various countries that none could doubt the poorness of the "quantity and quality of life" vouchsafed to

obtains to-day; not only does the Government draw food from north of the Great Wall, that is from Manchuria, but much food is now being produced and distributed from the province of Szechuan which is becoming in an increasing measure the great western granary of China. By this more even and controlled distribution of food, China has become almost self-sufficient in food; this does not mean of course that there are not still "three mouths for every two rice bowls" but rather that China's great waterways, railways and roads, as well as her great economical resources, are vastly improved in organization and administration and remarkably efficient in action. Within a generation or two fear of want, that is famine as the Chinese know it, could be removed. If there is any loss of personal liberty and intellectual freedom or fear of indoctrination or re-education and with it a fear of authority, then a far less optimistic situation will prevail in China; but the Chinese are both realistic and philosophical and are adepts at finding the middle way. Peace, however, is essential if progress is to be made in the development of the many plans envisaged for the nutritional improvement of the peoples of the Middle and Far East.

In marked contrast to the state of malnutrition in the East, the continent of Europe presents an entirely different picture. Where more rigid control is exercised over the price and distribution of food the present extremes of luxury and want could certainly be made to disappear. In the United Kingdom the food policy of the Government is still essentially that of war-time—rationing, price control, priorities and allowances to meet the needs of special groups. The policy is basically sound in that it has assured everyone of the possibility of obtaining a fair share of all essential foods. It is due to this policy that, except for fat, there has been no deficiency in nutrients in the diet of the various groups which make up the population and that clinically there is no evidence of a general lack of any specific nutrient. National flour has been fortified, table salt iodized and vitamins made available for infants and mothers; vulnerable groups have been cared for, the relation of diet to industrial output studied, and the general health of the nation and the nutritional factors upon which it depends effectively cared for by appropriate Ministries. Criticism of policy and procedure, however, has not been lacking, nevertheless the health of the people of this country, which has not only been

adequate importation of food grains strongly pressed in the International Emergency Food Council. One of the major difficulties in fulfilling the purpose of these plans is the lack of transport, both by rail and road. Owing to political changes in the country and the political unrest and communal disturbances which take place all too frequently, the position on the railways steadily deteriorated between 1947 and 1949 and bottle-necks at trans-shipment points and other important junctions through which heavy traffic passes continued to interfere with the smooth flow of traffic. During the year 1950 the transport situation improved. The food position was reviewed at a conference of Food Ministers of States in January 1950, when it was decided that the present policy of maximum procurement and the efforts to make food grains available to the people at reasonable prices should continue. It was further decided that after the year 1949, as rice is more expensive than other food grains, it should not be imported for the purpose of distribution, and, in order to increase local production, it was agreed to ban the polishing of rice in milling. The crop prospects for 1950–51 are satisfactory. The situation in India, otherwise hopeful, is still rendered much more difficult and uncertain by economic and political unrest.

China presents a far less clear picture than does India. Despite an atmosphere of uncertainty and suspicion the People's Government in Peking, since 1st October 1949, have shown no little ability in the efficient manner in which they have undertaken the tremendous task of administering a very much self-contained nation of almost 500,000,000 people. The interest [illegible]

wheat and even rice; to-day not one ton of these foodstuffs is imported, indeed rice has even been offered for export. The sending of grain from one province to another in times of famine was an old established custom of the Chinese Empire; it still

obtains to-day; not only does the Government draw food from north of the Great Wall, that is from Manchuria, but much food is now being produced and distributed from the province of Szechuan which is becoming in an increasing measure the great western granary of China. By this more even and controlled distribution of food, China has become almost self-sufficient in food; this does not mean of course that there are not still "three mouths for every two rice bowls" but rather that China's great waterways, railways and roads, as well as her great economical resources, are vastly improved in organization and administration and remarkably efficient in action. Within a generation or two fear of want, that is famine as the Chinese know it, could be removed. If there is any loss of personal liberty and intellectual freedom or fear of indoctrination or re-education and with it a fear of authority, then a far less optimistic situation will prevail in China; but the Chinese are both realistic and philosophical and are adepts at finding the middle way. Peace, however, is essential if progress is to be made in the development of the many plans envisaged for the nutritional improvement of the peoples of the Middle and Far East.

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maintained but improved during five years of blitzes, short rations and general alarms and five years of progressive austerity in the post-war period, is due originally to the fundamentally sound policy of Lord Woolton, Britain's war-time Food Minister.

None will deny that much still remains to be done if we are to see ourselves a strong and virile nation. If nutrition be the keystone, and well it may be, of the great arch of national fitness and prosperity, attention must nevertheless be given to those other stones without which the structure could not be raised. Amongst the many important things which do require consideration in the performance of this great task are maternal welfare with practical instruction in the care and upbringing of children, instruction in the principles of personal hygiene and public health, a further utilization of the land for the purpose of a greater production of animal and dairy products, vegetables and fruit, and lastly, and it is a point worthy of some attention, the maintenance of a well-ordered political life.

TABLE OF ENGLISH WEIGHTS AND MEASURES AND THEIR METRIC EQUIVALENTS

Ounce, fluid (British)	= 28 41 cubic centimetres
Ounce, fluid (U S.)	= 29 57 cubic centimetres
Pint, liquid (British)	= 20 fluid ounces (British)
	= 568 26 cubic centimetres
Pint, liquid (U S)	= 16 fluid ounces (U S)
	= 473 18 cubic centimetres
Gallon, (British Imperial)	= 10 pounds water (avoirdupois)
	= 8 pints, liquid (British)
	= 160 ounces fluid (British)
	= 277 3 cubic inches
	= 4 55 litres
Ounce (avoirdupois) (British)	= 1/16 or 0 0625 of a pound (avoirdupois)
	= 28 35 grams
	= 437 5 grains
Grain (gr)	= 0 0648 gram
Cubic Inch (in³ or cu. in.) (British)	= 16 39 cubic centimetres
Inch (British)	= 2 54 centimetres
Foot (British)	= 30 48 centimetres
Pound (avoirdupois) (British or U S)	= 27 69 cubic inches of water weighed in air at 4° C and 760 mm. Hg pressure
	= 16 ounces (avoirdupois)
	= 453 59 grams (avoirdupois)

BRITISH WEIGHTS AND MEASURES

Avoirdupois Weight

1 dram = 27 34 grains
1 ounce = 16 drams
1 pound = 16 ounces
1 quarter = 28 pounds
1 hundredweight = 4 quarters
1 stone = 14 pounds
1 ton (long) = 2,240 lb
1 ton (metric) = 2,204 lb

Apothecaries' Fluid Measure

1 drachm = 60 minims
1 ounce = 8 drachms
1 pint = 20 ounces
1 gallon = 8 pints
1 tablespoonful = 4 drachms
1 teacupful = 3 ounces

TABLE OF METRIC WEIGHTS AND MEASURES AND THEIR ENGLISH EQUIVALENTS

Litre (1)	= 1 76 pints (British)
	= 2 11 pints (liquid, U.S.)
	= 35 196 ounces (fluid, British)
	= 33 815 ounces (fluid, U S)
Millilitre (ml)	= 0 035 ounce (fluid, British)
	= 1 000 cubic centimetre
Cubic centimetre (cm ³, c.c.)	= 0 035 ounce (fluid, British)
	= 0 034 ounce (fluid, U.S)
Kilogram (kg.)	= 1000 grams.
	= 2 205 pounds (avoirdupois)
	= 35 274 ounces (avoirdupois)
Gram (g)	= 0 0022 pound (avoirdupois)
	= 0 035 ounce (avoirdupois)
	= 15 432 grains
Milligram (mg)	= 0 001 gram.
Microgram (μg)	= 0 001 milligram
Centimetre (cm)	= 0 394 inch
	= 10 0 millimetres
Metre (m.)	= 100 centimetres
	= 39 37 inches (British)
	= 3 28 feet (British)
Kilometre (km.)	= 1000 metres.
	= 0 621 mile (statute)

PRESSURE

Atmosphere (normal)—Pressure exerted by 76 cm. of Hg. density 13 595 g./cm.³	= 14 696 pounds per square inch
	= 29 921 inches mercury at 32° F.
	= 760 0 mm mercury at 0° C.

ENERGY

Kilogram-calorie, or large calorie (Calorie)	= 1000 calories (i e. small calories)
	= 3 97 (British) thermal units
	= 426 85 kilogram-metres

TEMPERATURE

Temperature degrees Centigrade (°C) = 5/9 (°F. − 32)
Temperature degrees Fahrenheit (°F) = 9/5 °C. + 32

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